Biographical Sketch

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A.I Education and Training

University of California, Davis	Davis, CA	Civil Engineering	B.S.	2005
Stanford University	Stanford, CA	Civil Engineering	M.S.	2007
Princeton University	Princeton, NJ	Civil Engineering	M.A.	2008
Northwestern University	Evanston, IL	Applied Mechanics	Ph.D.	2011
Sandia National Laboratories	Livermore, CA	Mechanics of Materials	Post-doc	2013

A.II Research and Professional Experience

Associate Professor	Columbia University	Since 2020
Assistant Professor	Columbia University	2014-2020
Senior Member of Technical Staff	Sandia National Laboratories	2013-2014
Postdoctoral Appointee	Sandia National Laboratories	2011-2013
Visiting Scholar	California Institute of Technology	2010-2011

A.III Research Interest

Machine learning for mechanics, computational mechanics, mechanics of porous media, multiscale modeling and meta-modeling of geological materials, geomechanics

B.I Major Awards (PI):

1. UPS Foundation Visiting Professor, Stanford University, 2022-2023 (postponed due to pandemic).
2. IACM John Argyris Award, International Association for Computational Mechanics (IACM), 2020.
3. NSF CAREER Award, Mechanics of Materials and Structures, National Science Foundation, 2019.
4. ASCE EMI Leonardo Da Vinci Award, American Society of Civil Engineers (ASCE), 2018.
5. Zienkiewicz Numerical Methods in Engineering Prize, Institution of Civil Engineers (ICE), 2017.
6. AFOSR Young Investigator Program Award, Air Force Office of Scientific Research, 2016.
7. Dresden Fellowship, Technische Universität Dresden, 2016.
8. ARO Young Investigator Program Award, Army Research Office, 2015.
9. Provost Diversity Award, Columbia University, 2015.
10. Caterpillar Best Paper Prize, Springer-Verlag Berlin Heidelberg, 2014.
11. John W. and Ernest L. Heinrich Scholarship, University of California Davis, 2004.

B.II Major Awards (Research Group Member):

12. Harold Agnew National Security Postdoctoral Fellowship (Eric Bryant), 2021.
13. Department of Defense Science, Mathematics and Research for Transformation (SMART) scholarship, Nhon Ngoc Phan, 2021.
14. Mindlin award (SeonHong Na, Kun Wang, Nikolaos Vlassis), Fu Foundation School of Engineering and Applied Science, Columbia University, 2018, 2019, 2021.
15. Dongju Lee Memorial Award (SeonHong Na), Department of Civil Engineering and Engineering Mechanics, Columbia University, 2017.

16. Department of Defense National Defense Science and Engineering Graduate Fellowship (NDSEG) (Jarett Poliner), 2020.
17. NSF/DOE Fellowship for conferences (Kun Wang, SES Texas A&M 2015, Yang Liu, USNCCM San Diego, 2015, SeonHong Na, ASCE EMI Stanford, 2015, Kun Wang & Chuanqi Liu (Meshless method workshop, Santa Fe, 2018, Kun Wang, 20th International Conference on Finite Elements in Flow Problems, Bahador Bahmani & Nikolaos Vlassis, USNCCM Chicago 2021).

C. Representative Publications (* indicates students or postdoc, total journal publication = 68, H-index= 28, i10-index=53 (Google scholar [URL]), Citation Percentile=87% [URL], as of 6/20/2021.)

Game/Graph-theoretic machine Learning for Constitutive modeling

1. K. Wang*, **W.C. Sun**, Q. Du, A non-cooperative meta-modeling game for automated third-party training, validating, and falsifying constitutive laws with adversarial attacks, *Computer Methods in Applied Mechanics and Engineering*, doi:10.1016/j.cma.2020.113514, 2021. [Video]
2. N. Vlassis, **W.C. Sun**, Sobolev training of thermodynamic-informed neural network for interpretable elasto-plasticity models with level set hardening, *Computer Methods in Applied Mechanics and Engineering*, doi:10.1016/j.cma.2021.113695, 2021. [Video][preprint]
3. B. Bahmani*, **W.C. Sun,** A kd-tree accelerated hybrid data-driven/model-based approach for poroelasticity problems with multi-fidelity multi-physics data, *Computer Methods in Applied Mechanics and Engineering*, 2021. [Video] [PDF]
4. N. Vlassis, R. Ma*, **W.C. Sun**, Geometric deep learning for computational mechanics Part I: Anisotropic Hyperelasticity, *Computer Methods in Applied Mechanics and Engineering*, doi:10.1016/j.cma.2020.113299, 2020. [PDF]
5. Y. Heider*, K. Wang*, **W.C. Sun**, SO(3)-invariance of graph-based deep neural network for anisotropic elastoplastic materials, *Computer Methods in Applied Mechanics and Engineering*, doi:10.1016/j.cma.2020.112875, 2020.
6. K. Wang*, **W.C. Sun**, Meta-modeling game for deriving theory-consistent, micro-structure-based traction-separation laws via deep reinforcement learning, *Computer Methods in Applied Mechanics and Engineering*, 346:216-241, doi:10.1016/j.cma.2018.11.026, 2019.
7. K. Wang*, **W.C. Sun**, Q. Du, A cooperative game for automated learning of elasto-plasticity knowledge graphs and models with AI-guided experimentation, arXiv:1903.04307, 2019.
8. K. Wang*, **W.C. Sun**, A multiscale multi-permeability poroplasticity model linked by **recursive homogenizations and deep learning**, *Computer Methods in Applied Mechanics and Engineering*, doi:10.1016/j.cma.2018.01.036, 2018.

Computational Poromechanics

9. H.S. Suh, **W.C. Sun**, An immersed phase field model for microporomechanics of fracture-induced leakage, *Physics of Fluids* (Editor's pick), doi:10/1063/5.0035602, 2021[short video][preprint]
10. C. Liu*, **W.C. Sun**, ILS-MPM: An implicit level-set-based material point method for frictional particulate contact mechanics of deformable particles, *Computer Methods in Applied Mechanics and Engineering*, 2020.
11. J. Choo*, **W.C. Sun**, Cracking and damage from crystallization in pores: Coupled chemo-poro-mechanics and phase-field modeling, *Computer Methods in Applied Mechanics and Engineering*, 335:347-379, doi:10.1016/j.cma.2018.01.044, 2018. [URL] (Impact factor = 4.821, number of citations=23.)
12. S. Na*, E.C. Bryant*, **W.C. Sun**, A configurational force for adaptive re-meshing of gradient-enhanced poromechanics problems with history-dependent variables, *Computer Methods in Applied Mechanics and Engineering*, doi:10.1016/j.cma.2019.112572, 2019.
13. S. Na*, **W.C. Sun**, Computational thermo-hydro-mechanics for multiphase freezing and thawing porous media in the finite deformation range, *Computer Methods in Applied Mechanics and Engineering*, 318:667-700, doi:10.1016/j.cma.2017.01.028, 2017. (Ph.D. Student SeonHong Na was selected as runner-up for the **2017 best paper competition at EMI Nashville**).

14. **W.C. Sun**, A stabilized finite element formulation for monolithic thermos-hydro-mechanical simulations at finite strain, *International Journal for Numerical Methods in Engineering*, 103(11):798-839, 2015. (This paper is one of the 5 **most cited papers** from 2015 to 2016 in IJNME, and is selected for the **Zienkiewicz Numerical Methods in Engineering Prize)**
15. **W.C. Sun**, M.R. Kuhn and J.W.Rudnicki, A multiscale DEM-LBM analysis on permeability evolution inside a dilatant shear band, *Acta Geotechnica*, 8(5):465-480, 2013. (Selected by the editorial broad as the best paper in 2013 (Authors received the **2013 Caterpillar Best Paper Prize)**.
16. **W.C. Sun**, J.T. Ostien, A.G. Salinger, A stabilized assumed deformation gradient finite element formulation for strongly coupled poromechanical simulations at finite strain, *International Journal for Numerical and Analytical Methods in Geomechanics*, 37(16):2755-2788, doi:10.1002/nag.2161, 2013.

Multiscale damage, fracture, plasticity of path-dependent materials

17. R. Ma*, **W.C. Sun**, C. R. Picu, Atomistic-model informed pressure-sensitive crystal plasticity for crystalline HMX, *International Journal of Solid and Structures*, accepted, 2021.
18. H.S. Suh*, D. O'Conner, **W.C. Sun**, A phase field model for cohesive fracture in micropolar continua, *Computer Methods in Applied Mechanics and Engineering*, 369:11381, doi:10.1016/j.cma.2020.113181, 2020. [Video]
19. R. Ma*, **W.C. Sun**, FFT-based solver for higher-order and multi-phase-field fracture models applied to strongly anisotropic brittle materials and poly-crystals, *Computer Methods in Applied Mechanics and Engineering*, 362:112781 doi:10.1016/j.cma.2019.112781, 2020.
20. R. Ma*, **W.C. Sun**, Computational thermomechanics for crystalline rock. Part II: modeling damage-plasticity, healing and precipitation creeps in strongly anisotropic polycrystalline materials, *Computer Methods in Applied Mechanics and Engineering*, doi:10.1016/j.cma.2020.113184, 2020.
21. E. C. Bryant, **W.C. Sun**, A mixed-mode phase field fracture for secondary cracks in anisotropic brittle rocks with consistent kinematics, *Computer Methods in Applied Mechanics and Engineering*, 342:561-584, doi:10.1016/j.cma.2018.08.008, 2018.
22. E. C. Bryant*, **W.C. Sun**, A micromorphic-regularized anisotropic Cam-clay for capturing size-dependent anisotropy of geomaterials, *Computer Methods in Applied Mechanics and Engineering*, 354:56-95, doi:10.1016/j.cma.2019.05.003, 2019.
23. S. Na*, **W.C. Sun**, Computational thermomechanics of crystalline rock. Part I: a combined multi-phase-field/crystal plasticity approach for single crystal simulations, *Computer Methods in Applied Mechanics and Engineering*, doi:10.1016/j.cma.2017.12.022, 2018.
24. Y. Liu, **W.C. Sun**, Z-F. Yuan, J. Fish, A nonlocal multiscale discrete-continuum model for predicting mechanical behavior of granular materials, *International Journal for Numerical Methods in Engineering*, 106(2):129-160, doi: 10.1002/nme.5139, 2016. [PDF] [Bibtex] (Ph.D. Student Yang Liu won the 2015 best poster competition at USNCCM San Diego).

D. Inventions and Software System

Albany/LCM: The PI implemented the finite and small strain poromechanics and thermo-hydro-mechanics finite element capabilities in Albany.

Deal.ii/Geocentric: The PI and his students have formulated, implemented, verified, and validated a frozen soil model and a finite strain thermo-hydro-mechanics model for frozen soil with unfrozen flow inside. Furthermore a phase field model for anti-crack has been implemented by the Columbia research team to study the propagation of compaction band.

DPS Deep learning poromechanics simulator: The PI and his students have formulated, implemented, verified, and validated a DEM-FEM model for dry, unsaturated, and saturated porous media. In the proposed model, the flow can be modeled via network or Lattice Boltzmann models. Recurrent neural networks trained via dataset fusion from experimental data and RVE sub-scale simulations are used as placeholders for multiscale computations.

E. Synergistic Activities

E.I Government/University Research Collaboration:

3-year experience as a senior member of technical staff and postdoctoral appointee at Sandia National Laboratories (SNL), during which the PI served as one of the developers of an open-source code called Albany for multi-physical numerical simulations. The ongoing research collaborations among the PI and members of SNL help the transfer of knowledge to national laboratories in the USA.

E.II Research Outreach:

- **Department seminars at universities:** UC Davis (2013), Carnegie Mellon University (2013), Brown University (2013, 2021) [Video], Duke (2018), Cornell (2019), University of Illinois, Chicago (2014), the University of Texas at Austin (2015), Hong Kong University of Science and Technology (2014, 2017), University of Hong Kong (2015, 2017), Technical University of Dresden, Germany (2015, 2019) and University of Perugia, Italy (2015), Ruhn-University Bochum, Germany (2016), Harvard University (2016), MIT (2017), Princeton (2017), Georgia Institute of Technology (2017), Penn State (2018), RPI (2018) and Stanford University (2019), University of Nottingham (2019), ETH Zurich (2020), USACM (2020) [Video], Johns Hopkins (2021) [Video].
- **Invited seminars at Government Laboratories:** Army Research Laboratory (2011), Naval Research Laboratory (2011), Lawrence Livermore National Laboratory (2013, 2016, 2019), Los Alamos National Laboratory (2011, 2015, 2018, 2019), Sandia National Laboratories (2013, 2015, 2017, 2018, 2019, 2021), Army Cold Region Research and Engineering Laboratories (2016).
- **Invited seminars from industries**: Shell (2013), Itasca Consulting Group (2014), ExxonMobil (2016, 2018), IBM Ireland (2019).
- **Diversity STEM outreach**: Participated in Inside Engineering Lab Visits and hosted Academy of the Holy Angels from New Jersey for a site visit and guest lecture; Secured grant from Army Research Office to host high school students for summer research in Summer 2018, summer 2019, and summer 2020 and 2021.
- **Guest editorship**, special issue on computational poromechanics (International Journal of Multiscale Computational Engineering, 2016), special issue on multiscale multi-physics computational mechanics of advanced materials (International Journal of Multiscale Computational Engineering, 2017), special issue on data-driven computational modeling and simulations (Computer Modeling in Engineering and Science, 2018).
- **Discussion leader** of the iMechanica Journal Club, (September 2014).

E.III Selected Service and Leadership to the Research Community:

- Founding vice-chair of the ASCE Engineering Mechanics, Machine Learning for Mechanics committee since 2020.
- Co-chair of Mechanistic Machine Learning and Digital Twins for Computational Science, Engineering and Technology, Mission Bay, San Diego MMLDT-CSET, scheduled 2021.
- C-chair of ASCE EMI Engineering Mechanics Institute Conference, New York, 2021.
- Co-chair of the International Symposium on Multiscale Computational Analysis of Complex Materials (with Christian Linder (Stanford) and Leon Mishnaevsky Jr (Technical University of Denmark), sponsored by Danish Agency of Science.
- Member of four ASCE Engineering Mechanics Institute committees (Computational Mechanics, Granular Mechanics, Elasticity, Poromechanics) since 2015, and the committee member of the Computational Geotechnics Committee of the ASCE Geo-institute.
- Chair of the local organization committee for World Congress of Computational Mechanics New York with more than 100 mini-symposia and more than 3500 talks and participants, 2018.
- Chair of the planning committee for the NSF-sponsored Verification & Validation of Computational Models Associated with the Mechanics of Materials Workshop, 2018.
- Organizer/co-organizer of more than 30 mini-symposia at WCCM, USNCCM, ASCE EMI conference.
- Reviewer of more than 40 different peer-reviewed journals.
- Reviewer/panelist to Army Corps of Engineering, Army Research Office, DOE Nuclear University Program, National Science Foundation (USA), German Research Foundation, European Union Liaison Office, National Science Center (Poland), Swiss National Science Foundation, Hong Kong Research Council.

- Editorial board member of International Journal for Multiscale Computational Engineering and Acta Geotechnica.
- Associate editor of Computer Modeling in Engineering and Science and Data-Centric Engineering.

E.IV Student Mentoring:

- Ph.D. graduate Yang Liu has won the **2015 USNCCM poster competition** among more than 100 mini-symposia. Ph.D. candidate SeonHong Na received **2nd place in best paper competition** from Modeling Inelasticity and Multiscale Behavior Committee, ASCE Engineering Mechanics Institute (2016).
- All Ph.D. graduates of the PI's research group have got tenure-track positions (Ying Liu, Northeastern University (2017; SeonHong Na, McMaster University) or postdoc positions from National Laboratory (Kun Wang and Eric Bryant, Theoretical Division, Los Alamos National Laboratory).
- Former Postdoc Jinhyun Choo has started his tenure-track position at the University of Hong Kong (ranked 7th in Asia in US News ranking) in 2018, while former postdoc Chuanqi Liu joined the Chinese Academy of Sciences as an associate professor in 2020.

F. Thesis supervised as primary Ph.D. advisor

1. Yang Liu, Multiscale Modeling of Granular Materials. Spring 2014- Spring 2016 (co-advised with Jacob Fish). Now an assistant professor at the Department of Mechanical and Industrial Engineering, Northeastern University. [URL]
2. SeonHong Na. Multiscale thermo-hydro-mechanical-chemical coupling effects for fluid-infiltrating crystalline solids and geomaterials: theory, implementation, and validation. Fall 2014-Fall 2018. Now an assistant professor of Civil and Environmental Engineering at McMaster University. [URL]
3. Kun Wang. From multiscale modeling to meta-modeling of poromechanics problems. Spring 2015 to Spring 2019. Now postdoctoral research scientist, Theoretical Division of Los Alamos National Laboratory since September 15th, 2019. [URL]
4. Eric Bryant. Capturing evolving size-dependent anisotropy from brittle fracture to plasticity for geological materials, Fall 2016-Spring 2020 (now Harold Agnew National Security Fellow, Theoretical Division of Los Alamos National Laboratory as a postdoctoral research scientist in summer 2020). [URL]
5. Nikolas Vlassis, Geometric deep learning from multi-graphs and manifolds for computational poromechanics, Ph.D. candidate, Fall 2017-Summer 2021.
6. Hyoung Suk Suh, Multiscale modeling of ice lens growth in frozen soil under changing climate, post-qualifying exam, Ph.D. candidate, Fall 2018-2022 (estimated). [Video]
7. Bahador Bahmani, Ph.D. student, Robust adaptive physics-informed neural network for path-dependent materials, pre-qualifying exam, since Fall 2019.
8. Jarett Stephen Lo Poliner, Ph.D. student, Constitutive modeling, verification and validation as a multi-agent on-cooperative game, since Fall 2020.
9. Zeyu Xiong, Ph.D. student, Data-driven plasticity and damage for energetic materials, since Fall 2020.
10. Mian Xiao, Ph.D. student, Topological-informed material point method for fracture and fragmentation simulations, since Fall 2020.

G. Research Funding

Sun research group is currently supported by the Department of Energy, Army Research Office, Air Force Office of Scientific Research, National Science Foundation (CMMI and EAR divisions), Department of Defense, Sandia National Laboratories, the National Nuclear Security Administration, and Columbia University. The PI received the Young Investigator Program Award from the Army Research Office in 2015, another Young Investigator Program Award from the Air Force Office of Scientific Research in 2017, and the NSF CAREER award from the Mechanics of Materials and Structures Program of National Science Foundation in 2019. Since joining Columbia in Spring 2014 and with a $40,000 startup fund, the PI has been awarded more than **5.86 million** US dollars for his research expenses (more than half from single-PI projects, the rest from MURI and other projects). The PI also joined forces in collaborative projects within the department, school, university, and with external collaborators on various other projects with the total support of **over 20.0 million dollars** since 2014.