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Vahidullah Tac

Machine Learning for Computational Mechanics

Research Interests: Senior PhD student working on applying novel machine learning techniques for solving problems in computational mechanics. I focus on integration of physical constraints in machine learning models, uncertainty quantification in data-driven models, supervised and unsupervised learning, generative AI and others for various problems in constitutive materials modeling.

Education

PhD **Purdue University**, West Lafayette, IN
2021 - now *Mechanical Engineering*
Dissertation title: Data-driven modeling of elastic and inelastic processes
Thesis advisor: Adrian Buganza Tepole
Expected date of graduation: July 2024

MSc **Middle East Technical University**, Ankara, Turkey
2016 - 2019 *Aerospace Engineering*
Thesis title: Micromechanical modeling of carbon nanotube – polymer composites

BSc **Middle East Technical University**, Ankara, Turkey
2012 - 2016 *Aerospace Engineering*

Research & Experience

Purdue University **Research Assistant**
2021 – now Conducted research into application of machine learning for solving problems in computational mechanics. Developed several models for mechanical phenomena such as hyperelasticity, viscoelasticity, continuum damage, and others. Developed an uncertainty quantification method for data-driven hyperelasticity using diffusion.

Stanford University **Visiting Researcher**
2024 – 2024 (2 mo) Conducted quantitative research on the concentration of tau and amyloid beta in the human brain.

Turkish Aerospace Industries (TAI) **Structural Design Engineer**
2018 - 2021 Designed various spacecraft parts such as structural panels, inserts and brackets. Spearheaded the development of the first structural panel with embedded active cooling in TAI.

TUBITAK Space **Research Engineer**
2017 - 2018 Designed and developed two engineering software packages for 1) aircraft conceptual design and 2) composite failure analysis as part of a highly dynamic team.

Awards & Honours

- **Travel for Collaborative Research (TRACER) Award ($10,000)**. From Purdue University, 2023. Used to travel to Stanford University for a 2-month collaboration.
- **SES Travel Award ($1,000)** from Society of Engineering Science (SES) to attend the Inaugural SES Future Faculty Symposium, 2023.
- **Robert J. Melosh Medal** for best student paper in computational solid mechanics, Duke University, 2022.
- **Ward A. Lambert Teaching Fellowship**, Purdue University, 2022
- **Ben M. Hillberry Graduate Scholarship ($3,600)**, Purdue University, 2022.
- **TUBITAK Publication Award** for publishing an article in the Journal of Composite Materials, 2020.
- **3rd Place,** Individual Aircraft Design Competition 2015-16, American Institute of Aeronautics and Astronautics (AIAA).
- **1st Place,** METU Engineering Day 2016 Poster Competition.
- **Study abroad scholarship** from the Ministry of Higher Education of Afghanistan for undergraduate studies.

Publications

[11] **V. Tac** and A. B. Tepole, "*A Modeler's Guide to Soft Tissue Mechanics*," in Comprehensive Mechanics of Materials (First Edition), V. Silberschmidt, Ed., Oxford: Elsevier, 2024.

[10] **V. Tac**, E. Kuhl, and A. B. Tepole, "*Data-driven continuum damage mechanics with built-in physics*," *Submitted*, 2024.

[9] L. Nunez Alvarez, J. Ledwon, S. Applebaum, B. Progri, T. Han, J. Laudo, **V. Tac**, A. Gosain, and A. B. Tepole, "*Tissue expansion mitigates radiation-induced skin fibrosis in a porcine model*," *Submitted,* 2024.

[8] **V. Tac**, M. K. Rausch, I. Bilionis, F. S. Costabal and A. B. Tepole, "*Generative hyperelasticity with physics-informed probabilistic diffusion fields*," *Submitted,* 2023.

[7] **V. Tac**, M. K. Rausch, F. S. Costabal and A. B. Tepole, "*Data-driven anisotropic finite viscoelasticity using neural ordinary differential equations*," *Computer Methods in Applied Mechanics and Engineering*, 2023.

[6] **V. Tac**, K. Linka, F. S. Costabal, E. Kuhl and A. B. Tepole, "*Benchmarks for physics-informed data-driven hyperelasticity,"* *Computational Mechanics*, 2023.

[5] **V. Tac**, F. S. Costabal, and A. B. Tepole, "*Data-driven tissue mechanics with polyconvex neural ordinary differential equations*," *Computer Methods in Applied Mechanics and Engineering*, 2022.

[4] **V. Tac**, V. D. Sree, M. K. Rausch, and A. B. Tepole, "*Data-driven modeling of the mechanical behavior of anisotropic soft biological tissue*," *Engineering with Computers*, 2022.

[3] Y. Leng, **V. Tac**, S. Calve, and A. B. Tepole, "*Predicting the mechanical properties of biopolymer gels using neural networks trained on discrete fiber network data*," *Computer Methods in Applied Mechanics and Engineering*, 2021.

[2] **V. Tac**¸ and E. Gürses, "*Micromechanical modelling of carbon nanotube reinforced composite materials with a functionally graded interphase*," *Journal of Composite Materials*, 2019.

[1] **W. Taj** and D. Coker, "*Dynamic frictional sliding modes between two homogenous interfaces*", IOP Conference Series: Materials Science and Engineering, 2018.

Teaching

ME 270 - Statics — **Lecturer**

Fall 2023

- I was the instructor for one of the sections of ME 270 – Basic Mechanics I as part of the Ward A. Lambert Teaching Fellowship.

ME 270 - Statics — **Guest Lecturer**

Spring 2023

- I taught 3 sessions of the class in preparation for my Fall 2023 class.

Technical Skills

- **Python** (Proficient in **Jax** and familiar with **TensorFlow** and **PyTorch)**
- **Machine learning** (Extensive experience with **Neural ODEs** and **Diffusion**)
- **FORTRAN**
- **Finite Element Method**
- Familiar with a variety of tools and languages such as **Julia, MATLAB, C, HTML, LaTeX** and others.