# Yizheng Wang (2024/8/23)

Phone: +86 17326912090 | Email: wang-yz19@tsinghua.org.cn

## EDUCATION BACKGROUND

**School of Aerospace Engineering, Tsinghua University (THU)** 08/2019–06/2022

- Professional Master in Aerospace Engineering, Overall GPA: 3.47/4.0 Beijing, China
- Core Courses: Machine Learning, Finite Element Method, Pattern Recognition, Applied Statistics, Numerical Analysis, Computational Solid Mechanics, Computational Dynamics, Tensor Analysis, Solid Mechanics, Experimental Solid Mechanics, Elastoplasticity

**Coursera Certificate on Deep Learning** 01/2020–03/2021

**College of Air Traffic Management, Civil Aviation University of China** 09/2012–07/2016

- Bachelor of Engineering in Transportation (Air Traffic Control), Overall GPA: 3.18/4.0 Tianjin, China

## PUBLICATIONS

- **Wang, Yizheng**, Xiaoying Zhuang, Timon Rabczuk, and Yinghua Liu. "AI for PDEs in solid mechanics: A review" Published on *Advances in Mechanics* (IF: 2.386). https://lxjz.cstam.org.cn/cn/article/id/aa8f9d5c-5e44-46d0-843a-95a2495caed9
- **Wang, Yizheng**, Jia Sun, Wei Li, Zaiyuan Lu, and Yinghua Liu. "CENN: Conservative energy method based on neural networks with subdomains for solving variational problems involving heterogeneous and complex geometries." Published on *Computer Methods in Applied Mechanics and Engineering* (IF: 7.188). https://doi.org/10.1016/j.cma.2022.115491
- **Wang, Yizheng**, Jia Sun, Jinshuai Bai, Cosmin Anitescu, Mohammad Sadegh Eshaghi, Xiaoying Zhuang, Timon Rabczuk, and Yinghua Liu. "Kolmogorov Arnold Informed neural network: A physics-informed deep learning framework for solving PDEs based on Kolmogorov Arnold Networks" *submitted to Computer Methods in Applied Mechanics and Engineering* (IF: 7.188) (under review). https://doi.org/10.48550/arXiv.2406.11045
- **Wang, Yizheng**, Jia Sun, Timon Rabczuk, and Yinghua Liu. "A deep complementary energy method for solid mechanics using minimum complementary energy principle." In Progress, prepare for submission to *International Journal for Numerical Methods in Engineering* (IF: 3.0). (Accept) https://doi.org/10.48550/arXiv.2302.01538
- **Yizheng Wang**, Xiang Li, Ziming Yan, Yuqing Du, Jinshuai Bai, Bokai Liu, Timon Rabczuk, Yinghua Liu. "HomoGenius: a Foundation Model of Homogenization for Rapid Prediction of Effective Mechanical Properties using Neural Operators." submitted to *Computer Methods in Applied Mechanics and Engineering* (IF: 7.188). https://www.researchsquare.com/article/rs-3994416/v1
- **Yizheng Wang**, Bokai Liu, et.al. "Deep Learning-Based Multi-Scale Modeling of Thermal Conductivity in Polyurethane with Phase Change Materials via Neural Operators." In Progress, prepared for submission to *Applied Energy* (IF: 11.2). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4702962
- Bokai Liu, **Yizheng Wang**, Timon Rabczuk, et.al. "Multi-scale modeling in thermal conductivity of Polyurethane incorporated with Phase Change Materials using Physics-Informed Neural Networks." Published on *Renewable Energy* (IF: 8.608). (https://doi.org/10.1016/j.renene.2023.119565
- Jia Sun, Yinghua Liu, **Yizheng Wang**, Zhenhan Yao, and Xiaoping Zheng. "BINN: A deep learning approach for computational mechanics problems based on boundary integral equations." Published on *Computer Methods in Applied Mechanics and Engineering* (IF: 7.188). https://doi.org/10.1016/j.cma.2023.116012

- Jinshuai Bai, Guirong liu, Timon Rabczuk, **Yizheng Wang**, et al. "A robust radial point interpolation method empowered with neural network solvers (RPIM-NNS) for nonlinear solid mechanics." Published on *Computer Methods in Applied Mechanics and Engineering* (IF: 7.188). https://doi.org/10.1016/j.cma.2024.117159
- Mohammad Sadegh Eshaghi, Mostafa Bamdad, Cosmin Anitescu, **Yizheng Wang**, et al. "DeepNetBeam: A Framework for the Analysis of Functionally Graded Porous Beams." Submitted to *Neurocomputing* (IF: 5.5) (Minor revison). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4846935
- **Wang, Yizheng**, and Yinghua Liu. "PETS-SWINF: A regression method that considers images with metadata based Neural Network for pawpularity prediction on 2021 Kaggle Competition 'PetFinder. My'." Submitted to *Pattern Recognition Letters* (IF: 3.756). https://doi.org/10.48550/arXiv.2201.06061

## CONFERENCES

**International Conference on Data-Driven Computing and Engineering Machine Learning 2022 (DACOMA-22),** Beijing, China 09/2022
Yizheng Wang. "Solving Partial Differential Equations of Solid Mechanics Based on PINN."
Won "**Best Paper Awards**" (*Master's Thesis Supervised by Prof. Yinghua Liu*)

**The 15th World Congress on Computational Mechanics (WCCM), 8th Asian Pacific Congress on Computational Mechanics (APCOM),** Yokohama Japan Virtual 07/2022
Yizheng Wang, and Yinghua Liu. "A Physics-informed Complementary Energy Form in Solid Mechanics." Presented at Minisymposium MS1716 "Data-driven Approaches in Computational Solid Mechanics."

**The First National Symposium on data-driven Computational Mechanics,** Dalian, China 05/2023
Yizheng Wang, and Yinghua Liu. "A deep complementary energy method for solid mechanics using minimum complementary energy principle." Oral Presentation at "Data-driven numerical simulation of complex mechanical behavior."

**CCCM2023,** Dalian, China 08/2023
Yizheng Wang, and Yinghua Liu. "Deep energy method based on the principle of possible work" Oral Presentation at "Artificial Intelligence and Its Applications in Computational Mechanics"

**CCSM2023,** Nanjing, China 04/2024
Yizheng Wang, and Yinghua Liu. "AI for PDEs in solid mechanics". Oral presentation and host in computaiontal solid mechanics.

**Seminar on Machine Learning and Methodology in Computational Mechanics,** Dalian, China 04/2024
Yizheng Wang, and Yinghua Liu. "AI for PDEs in computational mechanics". Oral presentation.

## RESEARCH EXPERIENCE

**Solving Partial Differential Equations of Solid Mechanics Based on PINN** Beijing, China
*Master Thesis Supervised by Prof. Yinghua Liu of Institute of Solid Mechanics (ISM) of THU*
09/2019–06/2022

- The project studies the application of PINN (Physics-Informed Neural Network) for solving mechanical partial differential equations and extends the existing DEM (Deep Energy Method) to solve complex non-uniform problems
- Proposed CENN, a conservative energy method based on neural networks with subdomains, where the admissible function satisfying the essential boundary condition without boundary penalty is constructed by the radial basis function (RBF), particular solution neural network, and general neural network

- Compared CENN with the strong form PINN, the loss term potential energy at the interfaces has the lower order derivative, showing higher efficacy and accuracy and less hyperparameters; CENN can apply to complex geometries based on the special construction of the admissible function, it outperforms when dealing with singularities, strong discontinuity, complex boundary, non-linear, and heterogeneous PDEs
- Proposed a DCM algorithm in the form of PINN based on the principle of minimum complementary energy; pointed out that DEM is suitable for handling full force boundary conditions, DCM is suitable for handling full displacement boundary conditions; performed numerical experiments showing that DEM and DCM outperforms the strong form of PINN in terms of computational efficiency

**2021 Kaggle Competition "PetFinder.my"** Beijing, China
*Supervised by Prof. Jun Zhu & Prof. Jie Tang of Department of Computer Science and Technology of THU*
09/2021–01/2022

- Developed an algorithm for rating the pawpularity (cuteness) of stray pets to improve animal welfare and find more adoption possibilities
- Proposed an image regression model called PETS-SWINF that can process the metadata which describes and provides abstract properties of the dataset images; it takes account both low-order and high-order features of metadata and adaptively adjusts the weights of the image model and the metadata model
- The result demonstrates a higher accuracy of the model with metadata, as the RMSE loss is 17.71876 compared 17.76449 without metadata for the test dataset
- The team ranked 18$^{th}$ out of 3537 in the Public Board of 2021 Kaggle Competition

**Finite Element Methods in Computational Solid Mechanics** Beijing, China
*Supervised by Prof. Xiong Zhang, Assoc. Prof. Yan Liu, and Assoc. Prof. Zhanli Liu of ISM of THU*
03/2020–06/2021

- Programmed a complete set of software for calculating linear finite element in solid mechanics, used C++ and MATLAB for linear elements, axisymmetric elements, and quadratic elements, used python for pre and post processors, wrote time integration algorithms for solving dynamic problems
- Studied nonlinear mathematical theories and linear dynamics in computational solid mechanics, wrote an Abaqus UMAT based on Fortran for solving complex deformation cases with intrinsic nonlinearity
- Performed force analysis for bridge design with the finite element programming, for which numerical experiment serves as an effective method to save the testing cost

**Numerical Tests on Methods for Solving Linear and Nonlinear Equation Systems** Beijing, China
*Supervised by Prof. Dinghui Yang of Department of Mathematical Sciences of THU* 09/2020–01/2021

- Studied the mathematical principles of direct and iterative methods, then conducted programming, and performed numerical experiments for comparison
- For the direct method to solve linear equations, applied the Gaussian elimination method which can select the pivot element automatically; for highly ill-conditioned Hilbert matrix, adopted iterative methods including J, GS, and SOR: The spectral radius for the problem using J method exceeds 1, while GS and SOR methods converge, therefore concluded that GS and SOR methods works better than J method
- Applied Newton's and Quasi-Newton methods to derive nonlinear equations, discovered that Newton's iterative method has a higher convergence rate than Quasi-Newton method, but the matrix inversion for each step is more compute-intensive, thus overall the Quasi-Newton method has a faster speed

**Real-time Face Mask Detection with YOLOv3** Beijing, China
*Supervised by Prof. Changshui Zhang of Department of Automation of THU* 04–06/2020

- Utilized the YOLOv3 algorithm to develop a model for real-time detection based on large number of photographs of people with face masks obtained from the internet, reached 0.774 of map@0.6 for the test set (https://github.com/AIZOOTech/FaceMaskDetection).

- The model can be embedded into public surveillance cameras to identify whether an individual is wearing a mask or not, thus significantly reducing human cost for pandemic prevention and control

**Training Machine Learning Models for Rainfall Prediction** Beijing, China
*Supervised by Prof. Changshui Zhang of Department of Automation of THU* 04–06/2020

- Adopted machine learning models including LSTM, ARIMA, GBRT, XGBoost to train and predict precipitation data from 122 weather stations worldwide, the results showed that the LSTM outperforms with the MAE of 0.0225 (hourly prediction), as well as advantages regarding correlation coefficient (r)

**2020 Baidu Star Developer Competition: Traffic Sign Detection and Scene Matching** Taiyuan, China
*Supervised by Researcher Kaiyuan Zhang of SIBD* 03–06/2020

- Participated in developing a traffic sign detection and recognition model, which can identify the features in two sets of image taken at different times in the same location and match the traffic signs
- Won the 12$^{th}$ place in the 2020 Baidu Star Developer Competition (out of 2,312 teams) for the first round, mainly took responsibility for implementing the target detection algorithm

**A Study of Physical Phenomenon of Water Spiders Based on Tensor Analysis** Beijing, China
*Supervised by Prof. Quanshui Zheng of ISM of THU* 09/2019–01/2020

- Applied tensor analysis to solve the Young-Laplace equation, compared the theoretical derivation with the experiment phenomena, explained the physical property that allows water spiders to walk on water; the finding can potentially contribute to innovative designs of micro aquatic devices and non-wetting materials

**Estimating the Permanent with Monte-Carlo Algorithm** Beijing, China
*Supervised by Prof. Heng Liang of Department of Automation of THU* 09/2019–01/2020

- Improved the efficacy for computing the permanent, a p-complete problem, namely the computation complexity doubles as the matrix size expands by one order, by implementing a Monte-Carlo Algorithm which rely on random sampling and probability distribution to obtain numerical results
- Comprehensively considered the impact of the number of scattered points on increasing the calculation time and improving the accuracy in application: for 3000 scattered points and 90% matrix density, the exact algorithm takes 3900 seconds while the Monte Carlo algorithm takes only 1864 seconds with the accuracy drops by 10.11%

## PROFESSIONAL EXPERIENCE

**Microsoft Research (AI4Science)** Beijing, China
*Research Assistant, Supervised by Senior Researcher Dr. Qi Meng* 11/2022–Present

- The AI4Science Team, directed by Dr. Distinguished Scientist Tie-Yan Liu, focuses on the climate and weather prediction with collaborative effort across disciplines encompassing computer science, mathematics, physical sciences, natural sciences, engineering, etc.
- Joined AI for PDE Group to investigate and develop innovative computational methods based on Physics-Informed Neural Network and operators such as DeepONet to achieve higher efficiency and more accuracy than traditional method

**Shanxi Intelligence Institute of Big Data Technology and Innovation (SIBD)** Taiyuan, China
*Research Assistant, Supervised by Researcher Kaiyuan Zhang* 06–08/2020

- Assisted in Scoliosis Detection Project, held responsibility of data processing and database maintenance, turned the data into JSON format and imported into MySQL, formatted the irregular data with regex in Python, performed data mining and analysis
- Participated for early stage implementation of algorithm implementation, applied Mask R-CNN, a deep neural network for semantic segmentation problem in computer vision, to identify the key points of the

spine in radiograph datasets obtained from major hospitals and make preliminary diagnosis regarding whether a scoliosis exists and demands further medical inspection

**Zhejiang Loong Airlines Co., Ltd.**, Xiaoshan, China *Flight Dispatcher* 09/2016–05/2018

- Took charge of the calculation of aircraft performance (mainly Airbus A320), used operational research methods to optimize the maximum take-off and landing weight
- Conducted route analysis and weather assessment, monitored different phases of the flight

## SKILLS AND AWARDS

**Computer Skills:** Python (proficient), MATLAB (proficient), PyTorch (proficient), Abaqus (competent), C++ (functional), Fortran (functional)

**Other Skills:** 3rd Place in the 200m Freestyle at the National Swimming Championships in China, National Pool Lifeguard Qualification in China, National Swimming Teaching Qualification in China, Flight Dispatcher Certificate, Aircraft Performance Engineer

**Honors and Awards:** Received multiple scholarships for academic excellence, Outstanding Contribution to the Student Union of THU, 2-times university-level commendations, 1-time college-level commendation, THU Star for Art and Sport Achievements, the 1st Prize for fresh graduates and new employees of Zhejiang Loong Airlines (2/95, 2016)