# Xin-Yang Liu

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## Education

- **University of Notre Dame** — Notre Dame, IN, USA
  *Ph.D. candidate - Computational Physics, Mechanical Engineering* — *Jan 2020 - Present*
  - **Advisor**: Professor Wang, Jian-Xun
  - **Research interests**: Scientific Machine Learning (AI4Science), Dynamic System Modelling and Controlling, Computational Fluid Mechanics (CFD), Numerical Methods, Neural Operators
  - *Expected graduation time: Flexible, End of 2024 - Summer of 2025*

- **Xi'an Jiaotong University** — Xi'an, Shannxi, China
  *Bachelor of science - Energy & Power Engineering; GPA: 3.82* — *Aug 2015 - June 2019*

## Experience

- **Google Research** — Remote
  *Project Intern* — *August. 2023 - Present*
  - Developing Synthetic Turbulence Inlet Generator, collaborating with Google Research.
  - Training Generative AI - diffusion model in the mesh-irrelevant latent space encoded by Conditional Neural Field.
  - Performed multi-gpu (distributed data parallel) training on Google Cloud Platform (GCP).

- GPU cluster configuration & management — Notre Dame, Mar, 2021 - Present
  - Individually Designed and Configured 8-node GPU cluster - `CoMSAIL` for my research group at Notre Dame. Set up distributed file system via Network File System (NFS).
  - Gradually expand `CoMSAIL` from single node server to multi-node, distributed file system cluster. `CoMSAIL` has served over 30 users during the 2 years of service.

## Publications — *Peer-reviewed journal paper*

- **Liu, X.Y.**, Zhu, M., Lu, L., Sun, H. and Wang, J.X., 2024. Multi-resolution partial differential equations preserved learning framework for spatiotemporal dynamics. *Communications Physics, 7*(1), p.31.

  ***Keywords***: Embedding Physics into Deep Learning Architecture; Multiphysics; U-Net; Vision Transformer (ViT); Compared with SOTA Neural Operators (e.g. FNO / PINO, (Pi-) DeepONet); Time series (spatiotemporal dynamics) prediction

- **Liu, X.Y.** and Wang, J.X., 2021. Physics-informed Dyna-style model-based deep reinforcement learning for dynamic control. *Proceedings of the Royal Society A, 477*(2255), p.20210618.

  ***Keywords***: Model-based Reinforcement Learning, Dynamic Control; Surrogate Modelling with Physics-informed Neural Network (PINN); Long-Short Term Memory (LSTM).

- Movahhedi, M.*, **Liu, X.Y.***, Geng, B., Elemans, C., Xue, Q., Wang, J.X. and Zheng, X., 2023. Predicting 3D soft tissue dynamics from 2D imaging using physics informed neural networks. *Communications Biology*, 6(1), p.541. *Equal Contribution

  ***Keywords***: Fluid-structure interaction (FSI); Immersed Boundary Method (IBM); Physics-informed Neural Network (PINN) for bio-mechanics

## Preprints under review

- **Liu, X.Y.**, Bodaghi, D., Xue, Q., Zheng, X. and Wang, J.X., 2024. Asynchronous Parallel Reinforcement Learning for Optimizing Propulsive Performance in Fin Ray Control. arXiv preprint arXiv:2401.11349. Submitted to *Engineering with Computers*

  ***Keywords***: Deep Reinforcement Learning; Dynamic Control; Large Scale Distributed Training with Slurm; Computational Fluid Dynamics (CFD); Fluid-structure interaction (FSI)

- Du, P., Parikh, M.H., Fan, X., **Liu, X.Y.** and Wang, J.X., 2024. CoNFiLD: Conditional Neural Field Latent Diffusion Model Generating Spatiotemporal Turbulence. arXiv preprint arXiv:2403.05940. Submitted to *Nature Communication*

  ***Keywords***: Diffusion Model (Generative AI, Deep Probabilistic Model), Conditional Neural Field, Turbulence (including Spatial Statistics, Time Series Analysis), Spatiotemporal Dynamics Generation.

## Papers in Progress (As First-author)

- CoNFiLD-inlet: Synthetic Inflow Turbulence Generation Based on Conditional Neural Field Encoded Latent Diffusion Model *Collaboration project with **Google research**, will be on Arxiv soon*

  ***Keywords***: Turbulence (including Spatial Statistics, Time Series Analysis), Computational Fluid Dynamics (CFD), Multiscale Simulation. Conditional Generative Model (Guided Diffusion).

- MuRFiV: A Multi-Resolution Finite-Volume Inspired Deep Learning Framework for Predicting Spatiotemporal Dynamics Presentation at Crunch seminar, *paper will be on Arxiv soon*

  ***Keywords***: Finite Volume, Multi-Scale, Surrogate Modeling for Spatiotemporal Dynamics

## Selected Conference Presentations

- **Liu, X.Y.**, Fan, X.T. and Wang, J.X. MuRFiV-Net: A Multi-Resolution Finite-Volume Inspired Neural Network for Predicting Spatiotemporal Dynamics APS DFD, November 2023
- **Liu, X.Y.** and Wang, J.X. Predicting parametric spatiotemporal dynamics by multi-resolution pde structure-preserved deep learning APS DFD, November 2022
- **Liu, X.Y.**, Bodaghi, D., Zheng, X., Xue, Q. and Wang, J.X. Accelerating deep reinforcement learning with physics-informed models and asynchronous parallel training SIAM UQ, April 2022
- **Liu, X.Y.** and Wang, J.X. Physics-informed Dyna-Style Model-Based Deep Reinforcement Learning for Dynamic Control. SIAM Annual Meeting (AN21), July 2021

## Honors and Awards

- USACM Thematic Conference on Uncertainty Quantification for Machine Learning Integrated Physics Modeling (UQ-MLIP) Travel Award Aug, 2024
- Society of Engineering Science Annual Technical Meeting (SES2022) funding support Oct, 2022
- $16^{th}$ U.S. National Congress on Computational Mechanics Conference Award May, 2021

## Skills

- **Coding**: Python, Julia, Matlab, C++, CUDA
- **Deep Learning Frameworks**: Pytorch, Jax, Flax, Haiku, Optax
- **Engineering software**: OpenFOAM, SolidWorks, Ansys Fluent
- **Other tools**: LaTeX, ParaView, Slurm