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Research Interests: Data-Driven Methods/Fluid Mechanics/Aircraft Design

Education

Northwestern Polytechnical University（Guaranteed Admission）GPA 88.4% 2023.09 – Present

- *Master* in Fluid Mechanics Advisor： Zhang Weiwei

Northwestern Polytechnical University GPA 3.815/4.1 2019.09 – 2023.06

- *Bachelor.* in Engineering of Aircraft design

Publications

1. Machine learning of skin friction distribution based on surface inviscid flow feature (in Chinese)
First Author Accept by **Chinese Journal of Theoretical and Applied Mechanics (EI)**

- Overview： During the author's undergraduate thesis, this work addresses the challenges in engineering wall friction drag estimation, namely the low accuracy of existing engineering algorithms and the high computational cost of Computational Fluid Dynamics (CFD). We propose a wall friction modeling method based on inviscid flow features. This approach establishes a correlation between inviscid flow characteristics and wall friction, enabling efficient prediction of wall friction, particularly in low-sample modeling scenarios. Compared to CFD, this method significantly reduces computational cost, has low requirements for computational grids, and offers fast solution speeds. Furthermore, to address the selection and construction of inviscid features, this paper proposes a feature selection method that combines physical knowledge with ensemble learning, underpinning the development of the core model. **This method was tested on subsonic cases with varying operating conditions and geometries, achieving an average concentrated force error of approximately 2%.**

2. Euler Equation Embedded Machine Learning Method for Wall Pressure and Skin Friction Distribution
First Author Accept by **Engineering Applications of Computational Fluid Mechanics (JCR Q1)**

- Overview： Extending our previous findings, this research further refines and advances a modeling methodology for aerodynamic force distribution by embedding the Euler equations. Positioned as a low-fidelity governing equation, the Euler solution effectively represents the inviscid flow field information at the boundary layer's edge, **thereby enabling robust predictions of boundary layer friction drag and pressure distributions in viscous regimes**. Crucially, the Euler solution itself encapsulates the dynamics of flow-geometry interactions due to its dependence on shape and flow parameters. Through the integration of the Euler equations, coupled with tailored network architectures and loss functions, our enhanced model is capable of predicting not only pressure and friction drag distributions but also exhibiting superior performance for challenging flow regimes, including **transonic strong shocks and flow separation**. Validation across a range of 2D airfoil and 3D wing cases under diverse operating conditions consistently yielded positive outcomes. Notably, this novel approach **reduces sample requirements by over 60%** and limits **concentrated force errors to approximately 2%** when compared to conventional aerodynamic modeling techniques.

3. Envisioning the blueprint: Aeronautics in large models era
First Student Author Accept by **Chinese Journal of Aeronautics (JCR Q1)**

- Overview： This review paper, co-authored with my advisor, examines the profound impact and future prospects of large model (LM) technologies on the aviation industry. The rapid advancement of LM technologies has reshaped the landscape of scientific research and is fundamentally altering researchers' core competencies. **The growth of machine learning and the proliferation of data have given rise to data-intensive research paradigms, which are now a central focus. However, complex real-world engineering applications present significant challenges regarding generalization and trustworthiness, compounded by the diverse and uneven quality of available data**. These issues considerably limit the effective application of LM technologies. **Consequently, a dual-driven research paradigm, integrating both data and knowledge, has become the indispensable path for building industrial large models.** This paradigm has already injected new vitality into various aspects of aircraft design, manufacturing, and operation, indicating that domain-specific large models will be a key area of future development.

Research Experience

➢ **Physics embedded Aerodynamic Modeling Methodology** 2022.11 – 2024.06

Principal Investigator —Zhang Weiwei

- Overview： With the advancement of artificial intelligence, machine learning has become a crucial tool for constructing aerodynamic surrogate models, with research typically focusing on flow field variables, concentrated loads, and distributed loads. However, building these models often requires extensive datasets and exhibits limited generalization, failing to meet the demands of engineering applications. To address the challenges of modeling with limited samples and the need for high generalization, we have developed an aerodynamic modeling approach that embeds low-fidelity equations. This method utilizes physical variables derived from low-fidelity equation solutions as input, assisting the model in achieving high-accuracy results. Validation on airfoil and wing cases across various flow conditions and geometries has demonstrated that this approach can reduce sample requirements by over 50% and exhibits good applicability to complex flow states such as shocks and flow separation.
- 2 paper published.

➢ **Goal-Oriented Manifold Learning Method for Dimension Reduction** 2024.08 – 2025.08

Principal Investigator —Zhang Weiwei / Kou Jiaqing

- Overview： For complex high-dimensional fluid mechanics problems, data-driven dimension reduction methods are commonly used for modeling and analysis. Traditional data-driven dimension reduction methods, such as Proper Orthogonal Decomposition (POD) and Dynamic Mode Decomposition (DMD), employ fixed dimension reduction operations, resulting in a deterministic reduced-dimensional space for the data. In contrast, machine learning-based dimension reduction methods, like Autoencoders (AE), aim for unsupervised compression of high-dimensional features, yielding an indeterminate reduced-dimensional space. However, in practical applications, it is often desirable for the reduced-dimensional space to be correlated with specific targets, facilitating subsequent modeling or goal-oriented analysis. Therefore, we have developed a goal-oriented manifold learning method that, by incorporating a target loss within a convolutional autoencoder, discovers a simple manifold space associated with the target. Leveraging this method, we have further accomplished two tasks. By exploiting the correlation between the manifold space and aerodynamic force targets, we have constructed a filter in aerodynamic optimization tasks, effectively accelerating the optimization process. Concurrently, for the construction of surrogate models, we propose a sampling method tailored to the output space, enabling customized sampling within the output domain.
- Preparing 《Efficient Aerodynamic Shape Optimization Using a Goal-Oriented Manifold Geometric Filter》

➢ **Generative Design Method for Aerodynamic Shapes Based on Diffusion Models** 2025.07 – 2025.09

Principal Investigator —Zhang Weiwei / Kou Jiaqing

- Overview： In recent years, generative models such as Variational Autoencoders (VAE), Generative Adversarial Networks (GAN), and Denoising Diffusion Probabilistic Models (DDPM) have developed rapidly, offering new perspectives for aerodynamic shape design. We have developed a generative design method for aerodynamic shapes based on Denoising Diffusion Probabilistic Models. By employing classifier-free guidance, we achieve conditional control over the generation results based on aerodynamic performance metrics like lift-to-drag ratio, enabling the design of airfoils and blended-wing-body (BWB) configurations. Concurrently, we have developed a joint generative-optimization method that significantly improves the conditional accuracy of generated results with a small number of samples. In this work, we also compare mainstream generative models on generation tasks.
- This research is currently ongoing, with an estimated output of one paper.

Awards

Northwestern Polytechnical University Outstanding Undergraduate Student Pacesetter (Selected from all undergraduates campus-wide, 10 recipients) October 2022

Xiaomi Special Scholarship (Selected from all undergraduates and postgraduates campus-wide, 10 recipients) October 2022

Shaanxi Provincial Outstanding Graduate August 2023

Northwestern Polytechnical University Outstanding Undergraduate/Postgraduate Student 2020~2024

Personal Statement

- Technical Skills: Python, MATLAB programming. Proficient in PowerPoint, Word, LaTeX. 3D modeling (e.g., CATIA).
- CFD fundamentals: Pointwise meshing, ANSYS Fluent, PHengLEI solvers, Tecplot post-processing.
- Demonstrated strong organizational and management skills: Served as Executive Chairman of the Student Union in the School of Aeronautics at Northwestern Polytechnical University during undergraduate studies, and as Class Academic Representative. Demonstrated strong organizational and management skills.
- Genuine, frank, and courageous in taking on responsibilities, with a good capacity for handling pressure. Actively cultivates personal abilities outside of work. Hobbies include photography, hiking, badminton, calligraphy, seal carving, and playing traditional Chinese musical instruments (bamboo flute, hulusi).