Zhiheng Chen

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EDUCATION

08/2024-06/2026 **Cornell University** ***New York, USA***

- **Degree**: *Master of Science* in Mechanical Engineering
- **GPA**: 3.7/4.0

09/2020-06/2024 **University of Wisconsin Madison** ***Wisconsin, USA***

- **Degree**: *Bachelor of Science* in Mechanical Engineering
- **GPA**: 3.7/4.0

PUBLICATION

[1] **Z. Chen** and W. Wang. Modeling Elastic-Body Dynamics of Fish Swimming Using a Variational Framework. *IEEE Robotics and Automation Letters (RA-L, under review)*. arXiv:2509.16145.

[2] **Z. Chen** and W. Wang. Dynamic Modeling and Efficient Data-Driven Optimal Control for Micro Autonomous Surface Vehicles. *2025 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2025).* arXiv:2509.06882. (*Accepted*)

[3] K. Macauley, **Z. Chen,** and W. Wang. MicroASV: An Affordable 3D-Printed Centimeter-Scale Autonomous Surface Vehicle. *2025 IEEE International Conference of Robotics and Automation (ICRA 2025)*. DOI: 10.1109/ICRA55743.2025.11127526.

[4] Y. Wang, J. Kang, **Z. Chen**, and X. Xiong. Terrestrial Locomotion of PogoX: From Hardware Design to Energy Shaping and Step-to-step Dynamics Based Control. *2024 IEEE International Conference of Robotics and Automation (ICRA 2024)*. pp. 3419-3425. DOI: 10.1109/ICRA57147.2024.10611545. (*Co-first author*)

RESEARCH EXPERIENCE

05/2025-Ongoing **Robotic Fish Dynamics Modeling Research Project** ***UW Marine Robotics Lab***

- Working on the dynamics modeling of a flexible robotic fish. The model captures the continuously distributed elasticity of a deformable fish body undergoing large deformations and incorporates fluid-structure coupling effects;
- Built the model based on Hamilton's principle, modeling the head with generalized coordinates and the body with continuous displacement fields;
- Derived the kinetic and potential energy functionals and the virtual works from applied forces (water reactive and drag forces, joint motor torque), and applied Ritz series approximations to obtain the projected weak form of the equations of motion via automatic differentiations in Julia;
- Coded up a working simulation of the system dynamics in Julia;
- Currently working on design analysis, parameter optimizations, and controller design of the robotic fish.

10/2024-Ongoing **Research Project SINDy** ***Cornell University CCCS Group***

- Working in the Control and Computation for Complex Systems (CCCS) group at Cornell. Currently doing research on the Sparse Identification of Nonlinear Dynamics (SINDy) algorithm with a special focus on the weak-form SINDy;
- Have written working codes in Python and MATLAB for SINDy and weak-form SINDy, and assessed the performance of the two algorithms at different levels of observation noise and different basis function libraries;
- Planning to improve the weak-form SINDy by implementing Fourier mode test functions.

05/2024-01/2025 **Research Project MicroASV** ***UW Marine Robotics Lab***

- Worked on the MicroASV project in UW Marine Robotics Lab. The team fabricated a micro autonomous surface vehicle (MicroASV), aiming to create and control a swarm of MicroASVs [1], [2];
- Responsible for the physics-driven dynamics modeling and simulation for the MicroASV. The dynamics model includes the MicroASV rigid body, thrust forces from its four impellers, and fluid drag and added mass effect. Built a MATLAB simulator based on the dynamics model;
- Responsible for building an efficient data-driven modeling algorithm based on the weak formulation of governing equations;

- Built PID and LQR controllers for trajectory tracking tasks of MicroASV;
- Built an optimal controller based on variational principles and two-point boundary value problems, whose system dynamics was obtained from the data-driven modeling algorithm;
- Coded up a quadratic programming-based projection algorithm to guarantee non-negative thruster forces.

05/2023-09/2023 Research Project PogoX ***WELL Robotics Lab***

- Worked in a research team on the PogoX project in Wisconsin Expeditious LeggedAI Lab (WELL). The team added a pogo stick-style leg to a quadrotor drone (the system is named PogoX), and achieved single-legged hopping with controlled jump height and forward speed [3];
- Responsible for the 3D hybrid dynamics modeling for hopping, consisting of the aerial phase and stance phase continuous dynamics, and the touch-down discrete impact mapping;
- Built a simulator using MATLAB based on the hybrid dynamics model, and built an aerial phase PD orientation controller based on inverse dynamics in the MATLAB simulator;
- Evaluated the cost of transport of PogoX in the simulation, comparing the cost of transport to that of an ordinary quad-rotor drone, and made design analysis on PogoX, finding relationships between thrust-to-weight ratio, leg spring stiffness, and jump height;
- Responsible for data processing of the propeller motor testing, finding the relationship between the propeller thrust force and the motor PWM duty cycle.

COURSE PROJECTS

05/2025 EKF-ST Algorithm Design for Simultaneous State Estimation and Equation Learning

- Devised a new algorithm (named as EKF-ST) that combines the extended Kalman filter with sequential thresholding techniques; EKF-ST enables simultaneous and recursively refined state estimations and sparse system identifications for nonlinear dynamical systems;
- Given an equation in the governing equations not fully known, the EKF-ST algorithm models the equation as a linear combination of candidate basis functions with coefficients;
- The EKF-ST algorithm adds a thresholding process to the original EKF prediction-update loops to prune the spurious basis functions and the corresponding covariances;
- Tested the algorithm on the Lorenz system with process noises and noisy partial state measurements.

04/2025 Molecular Configuration Computations based on Numerical Optimizations and MATLAB

- Coded up numerical optimization algorithms in MATLAB to compute the configurations of clusters of neutral atoms, minimizing the Lennard-Jones potential;
- Implemented gradient descent and damped Newton's method to compute 2, 3, and 5-atom configurations, using Armijo's condition and backtracking to determine step sizes.

03/2025 Image Compression and Recovery Based on Numerical Linear Algebra and MATLAB

- Developed algorithms to compress images and recover masked images, and implemented the algorithms in MATLAB;
- Coded up an alternating least squares solver based on Householder QR to solve the matrix least squares problem for image compressions, and compared the results to the image compression results from the singular value decomposition;
- Modified the alternating least squares algorithm by adding regularization terms and unknown entries, and coded up the algorithm for recovering masked images.

02/2023-05/2023 Reduction Gearbox Design Based on Mechanics, SolidWorks, MATLAB and EES

- Worked in a team to design a reduction gearbox for a racing go cart;
- Responsible for the force analysis of the input shaft, counter shaft, output shaft, and gears using EES;
- Responsible for the static Von Mises stress, gear tooth bending and surface fatigue, and shaft fatigue analysis using MATLAB and EES;
- Represented the final design of the input shaft using SolidWorks.

09/2021-12/2021 Electric Trolley Fabrication Based on SolidWorks, EES and Arduino

- Fabricated an electric trolley that can move along tracks and maintain a specified distance from moving obstacles stably;
- Responsible for transmission design: given poor tolerances, achieved the transmission by using two sets of pulleys, and

calculated the optimal gear ratio using EES;

- Responsible for SolidWorks modeling: built the model of the two sets of pulleys based on the calculated gear ratio, and modeled the overall layout of the car, including the breadboard, Arduino microcontroller, distance sensor, pulleys, motor, and batteries;
- Responsible for Arduino programming: programmed the motor PWM, the distance sensor, and a preliminary controller for distance control.

CORE SKILLS (*: Learned in courses and used in projects; otherwise coursework-based)

Dynamics:

- *Mechanics**: Kinematics and kinetics of three-dimensional motions, Constraints, Configuration spaces, Newton-Euler equations, Energy and momentum methods, Lagrange's equations, Hamilton's principle and Ritz series method, Mechanical vibrations (matrix formulation and modal analysis, dynamic imbalance, Fourier analysis), Fluid drag and added mass, Hybrid dynamics modeling, Computational methods for dynamics simulations;
- *Nonlinear dynamics*: Fixed points, Limit cycles, Local stability analysis, Lyapunov functions, Poincaré maps and Floquent multipliers, Bifurcations, Chaotic attractors;
- *Data-driven modeling**: Sparse Identification of Nonlinear Dynamics (SINDy), Weak-form SINDy;

Model-Based Estimation and Control:

- *Parameter estimations*: Weighted least squares*, Maximum likelihood, Minimum mean square error, Recursive least squares;
- *Recursive Bayes filters*: Kalman filter (KF)*, Extended KF*, Unscented KF, Information filter and sensor fusions, Particle filter;
- *Control*: State feedback*, Linear-quadratic regulators*, Optimal control by variational principles and two-point boundary value problems*, Cascaded PID control*, Frequency domain techniques;

Numerical Analysis:

- *Numerical linear algebra*: Matrix factorizations (LU, Cholesky, QR*, singular value decomposition*), Eigenvalue problems (power method, Rayleigh iterations, QR algorithm);
- *Numerical optimizations*: Search direction methods (gradient descent*, Newton's method*, BFGS, Gauss-Newton), Constrained optimizations (KKT conditions*, quadratic programming*, sequential quadratic programming), Trust region methods;

Programming Languages: MATLAB*, Julia*, Python*, R;

AUXILIARY SKILLS

Mechanical Design Analysis: Stress, wear, and fatigue analysis for machine components*, FEA analysis for stress distributions and design optimizations;

Energy Systems: Energy and entropy balances for thermal systems, Heat transfer analysis;

Software: SolidWorks*, ROS, LabVIEW, EES*, LaTeX*;

Hardware: Lathe, Mill, Soldering iron*, Arduino*, DAQ modules, Tensile test machines;

ACTIVITIES

04/2025	Reviewer of 2025 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2025); reviewed the paper "Learning Flow-Adaptive Dynamic Model for Robotic Fish Swimming in Unknown Background Flow" authored by Chao et al.
04/2023-Present	Member of the Tau Beta Pi Engineering Honor Society
10/2022-Present	Member of the Pi Tau Sigma International Mechanical Engineering Honor Society

ADDITIONAL

Award: Excellence Award of Princeton University Physics Competition (PUPC), 10/2019;

Languages: Chinese Mandarin (native), English (fluent), Japanese (intermediate);

TOEFL: 110 (Reading27, Listening27, Speaking27, Writing29), 03/2018;

GRE: Verbal 158 (78%), Quantitative 170 (96%), AW 4.0 (54%), 09/2022;

Hobbies & Interests: Swimming, Boxing, Rope skipping, Novels, Table tennis, Sculling;