CHEN Zhiheng

152 Summerhill Drive, Apt 8, Ithaca, NY 14850
+1 608-886-7861 / +86 186-4206-2053 | ericczh1@outlook.com / zc548@cornell.edu

EDUCATION

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

- **Degree**: *Bachelor of Science* in Mechanical Engineering
- **Selected Core Courses**: Dynamics; Advanced Dynamics; Mechanics of Materials; Mechanical Vibrations; Thermodynamics; Fluid Dynamics; Dynamic Systems; Electrical and Electronic Circuits; Engineering Measurements and Instrumentation; Introduction to Feedback Controls for Mechanical Engineers; Introduction to Robotics; Computer Aided Engineering; Design of Machine Elements; Data Science Programming I; Calculus and Analytical Geometry; Calculus: Functions of Variables; Linear Algebra and Differential Equations; Introductory Applied Statistics for Engineers.

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

- **Degree**: *Master of Science* in Mechanical Engineering
- **Courses**: Nonlinear Dynamics and Chaos; Model-Based Estimation; Numerical Analysis: Linear and Nonlinear Problems; Formal Methods for Robotics.

PAPERS

[1] **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).* (Under review)

[2] 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)*.

[3] 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)*. (Co-first author)

RESEARCH PROJECTS

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

- Working on the three-dimensional dynamics modeling of a flexible robotic fish. The robotic fish is modeled as a rigid head and an elastic body connected by a revolute joint. Interactions with surrounding water are also modeled;
- Built the model based on Hamilton's principle, modeling the head with generalized coordinates and the body with continuous displacement fields;
- Derived expressions for the energy functionals and the virtual works from applied forces (water reactive and drag forces, buoyancy, joint motor torque, and pectoral fin lift and drag forces);
- Currently working on Ritz series discretization to obtain differential equations ready for numerical integrators.

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

- Working in the Control and Computation for Complex Systems (CCCS) group at Cornell University. 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 in 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 in 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 (the code and the report are available at the EKF-ST GitHub Repository I created).

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 analysis and safety factor calculations for the output shaft using MATLAB;
- Responsible for the gear tooth bending fatigue analysis of the counter shaft pinion and the output shaft gear using EES;
- Responsible for the surface fatigue analysis of the counter shaft pinion and the output shaft gear using EES;
- Responsible for the fatigue analysis, retaining ring, groove, and shoulder design of the input shaft using EES;
- Represented the final design of the input shaft using SolidWorks.

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

- Aimed to fabricate an electric trolley that can move along tracks and maintain a specified distance from moving obstacles stably;
- Responsible for transmission design: Under the circumstances that the tolerance could not be controlled precisely, achieved the transmission by using two sets of pulleys, and calculated the optimal gear ratio with 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 PWM for the motor and programmed the distance sensor with C++.

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, Fluid drag and added mass, Hybrid dynamics modeling, Computational methods for dynamics simulations;
- *Vibrations*: Free and forced responses, Matrix formulation and modal analysis, Orthogonality and modal coordinates, Dynamic imbalance, Damping models, Fourier analysis*, Aliasing and leakage, FEA modal analysis;
- *Nonlinear dynamics*: Fixed points, Limit cycles, Local stability analysis, Lyapunov functions, Poincaré maps and Floquent multipliers, Bifurcations, Hysteresis, 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 (Laplace transform, transfer functions, Nyquist stability, Bode plots and lead-lag compensations);

Numerical Analysis:

- *Numerical linear algebra*: Matrix factorizations (LU, Cholesky, QR*, singular value decomposition*), Eigenvalue problems (power method, Rayleigh iteration, 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*, 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 machine, Polymer extruder, Thermoforming machine;

ACTIVITIES

04/2025	Reviewer for 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;

Hands-on Experience: Disassembled and assembled two four-cylinder engines, two manual transmissions and one automatic transmission under the supervision of technicians (summer 2021);

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