Yifan Wang

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Research Profile

Robotics Ph.D. researcher working at the intersection of continuum/soft robotics, medical robotics, mechanics modeling, physics-inspired learning, planning, estimation, control, and robotic hardware development. Research spans design, theoretical formulation, numerical optimization, simulation, system integration, and experimental validation.

Research Interests

Continuum and soft robotics; medical robotics; motion planning with contact; robot mechanics and Cosserat rod modeling; state estimation and system identification; learning-based dynamics; model-predictive control; robot design and mechatronics.

Education

Georgia Institute of Technology — Atlanta, GA
Ph.D. in Robotics, GPA 4.0/4.0 — *2022 – Expected 2027*

- Dissertation: *[Title]*
- Advisor: Prof. Yue Chen

Shanghai Jiao Tong University — Shanghai, China
M.S. in Mechanical Engineering, GPA 3.85/4.0 — *2019 – 2022*

- Thesis: *Inverse Kinematics and Nonlinear Actuation Compensation for Continuum Robots*
- Advisor: Prof. Kai Xu

B.E. in Mechanical Engineering, Grade: 89.73/100 (rank 2/150), — *2015 - 2019*

- Thesis: *Teleoperation and Path Planning for Robotic Ureteroscopy*
- Advisor: Prof. Kai Xu

Research Experience

Georgia Institute of Technology — Atlanta, GA
Graduate Research Assistant — *2022 – Present*

Learning-Based Modeling and Control of Continuum Catheters — *Ongoing*

- Developing hybrid physics/data-driven dynamic models for tendon-driven continuum robots with unobservable proximal states and constraints, retaining a distal Cosserat model while learning the residual dynamics and the reduced-order proximal dynamics with backlash/friction.
- Built SOFA-based simulation and reduced-order learning pipelines based on Bayesian smoothing and regression; evaluated factor-graph-based sparse-sensor state estimation and MPPI/MPC for model-based control.
- Designed EM- and stereo-vision-based shape-tracking experiments for real-robot system identification and Bayesian estimation of hidden states and model parameters from distal shape/pose observations. Developing domain randomization and meta-learning algorithms for transferring from simulation and limited real-world data to new hardware with few-shot data.

MR-Conditional Cardiac Catheter Robotics — *Ongoing*

- Designed a compact MR-conditional robotic platform for simultaneous 6-DoF actuation of commercial deflectable cardiac catheter and sheath using nonmagnetic piezoelectric motors and modular handle adapters.
- Implemented Teensy-based firmware and control circuitry, ROS2-based estimation and control stack, and a 3D Slicer module for graphical user interface.
- Developed adaptive constant-curvature kinematics and closed-loop resolved-rate control with online shape fitting from electromagnetic tracking feedback.

- Achieved < 2 mm average and < 4 mm maximum tip-position error in benchtop path following; the robot functionality was validated both in phantom and in live animal trials in an MRI scanner at JHU.

Patient-Specific Multi-Catheter Device for Intracranial Convection-Enhanced Delivery *Ongoing*

- Developed a patient-specific device that routes six flexible infusion catheters from a single burr hole toward independently specified intracranial targets using an Ommaya-like reservoir, skull-mounted fixture, and a compact 4.2-mm-diameter guiding sheath with PTFE-lined curved channels.
- Formulated a hierarchical design pipeline that optimizes sheath pose and reduced-order B-spline channel geometries under geometric/manufacturing constraints, and derived a physics-informed catheter insertion-force surrogate from Cosserat-rod equilibrium and frictional contact for mechanically feasible optimization.
- Generated feasible designs for five tumor geometries and fabricated all five prototypes; free-space EM tracking measured a 1.80 mm mean catheter-tip position error; agarose infusion experiments achieved effective planned distribution.

Topology-Informed Motion Planning for Continuum Robots With Contacts

- Formulated quasi-static continuum robot mechanics under distributed elastic contact using Cosserat rod theory. Proved that stable configurations form a manifold and developed AtlasRRT*-based planning.
- Subsequently introduced a topology-informed quotient-space graph of contact modes using graph-of-convex-sets search, B-spline collocation, and energy minimization for complex 3D environments. Developed a hierarchical planning algorithm that reduces manifold sampling by quotient-space planning.
- In simulated environments, the implicit-manifold planner reduced computation time by 48–66% versus Euclidean-space RRT baselines while reaching target configurations that actuation-space planning failed. The quotient-space planner further reduced computation time by 50–90% and increased success rates by up to 24%.

MR-Safe Robotic Positioning for Active Shimming Against Implants

- Designed and fabricated a three-axis MR-safe Cartesian robot with 140 mm travel per axis using nonmetallic lead-screw stages and pneumatic actuation to position a > 3 kg cardiac shim coil inside MRI.
- Derived mechanical models for bearing loads, stress, and structural deflection and integrated fiber-optic encoders, limit sensing, remote mechatronic control, and an emergency-stop workflow.
- Achieved < 2 mm average motion error and 0.5 mm repeatability, reducing the manual adjustment step from > 5 minutes to a few seconds; validated the system in phantom and pre-clinical animal experiments at JHU.

Shanghai Jiao Tong University Shanghai, China
Graduate Research Assistant, School of Mechanical Engineering *2019 – 2022*

Hysteresis Compensation for Multi-Segment Continuum Robots *Jun. 2021 – Sept. 2021*

- Developed a modified multi-input Prandtl–Ishlinskii model for actuation hysteresis and combined it with Cosserat-rod mechanics and local Gaussian-process regression to compensate residual model error.
- Validated the method on a 96 mm, 2-segment, 4-DoF Ni-Ti-actuated continuum robot, reducing average open-loop end-effector pose error from 3.7 mm / 3.3° to 1.8 mm / 1.7°.

Efficient Inverse Kinematics and Dexterous Workspace Formulation *Sept. 2020 – May 2021*

- Developed a variable-separation IK method for two-segment inextensible continuum robots that reduces a six-dimensional IK problem to a one-dimensional nonlinear equation using a piecewise-line geometric representation.
- Derived analytic dexterous-workspace boundaries for handling unreachable target orientations; over 500,000 simulation cases, reduced computation time by more than 96% versus conventional Jacobian-based method and achieved 100% IK success.

Configuration-Transition Control of Multi-Segment Continuum Robots *Mar. 2020 – May 2020*

- Used a multilayer perceptron to adapt linear/angular task priorities during insertion and retraction, reducing configuration-transition IK failure rate from 6% to 0.82%.
- Developed a constrained-velocity-polytope manipulability controller that steers the robot away from local minima, further reducing the IK failure rate from 6% to 0.32%.

Shanghai Jiao Tong University Shanghai, China
Undergraduate Researcher, School of Mechanical Engineering *2019*

Flexible Endoscope Robot: Design, Teleoperation, and Path Planning *Mar. 2019 – Jun. 2019*

- Designed and assembled a transmission module for robotic manipulation of a flexible endoscope and implemented haptic teleoperation using a Geomagic Touch master device.
- Developed an artificial-potential-field planner for navigating the flexible endoscope through a kidney model.

Publications

Manuscripts in Preparation

1. Y. Wang, L. Michaelides, and Y. Chen, "A Multi-Catheter Device for Therapeutic Intracranial Infusion via Convection-Enhanced Delivery," manuscript in preparation.

2. Y. Wang, L. Ai, A. Kolandaivelu, E.J. Schmidt, J. Tokuda, and Y. Chen, "Real-time MR-guided Robotic Cardiac Ablation," manuscript in preparation.

Journal Articles

1. Y. Cai*, Z. Huang*, Y. Wang, H. Xu, Y. Chen, "Evolutionary diversification via modular compliance for self-reconfigurable continuum robots," *Science Advances*, 2026, in press.

2. Y. Wang and Y. Chen, "Topology-Informed Quasi-Static Motion Planning for Continuum Robots With Contacts," *IEEE Robotics and Automation Letters*, vol. 10, no. 11, pp. 11888-11895, Nov. 2025.

3. Y. Cai, H. Xu, Y. Wang, D. Chen, W. Matusik, W. Shou, Y. Chen, "Modular Self-Reconfigurable Continuum Robot for General Purpose Loco-Manipulation," *IEEE Robotics and Automation Letters*, vol. 10, no. 2, pp. 1976-1983, Feb. 2025.

4. A.L. Gunderman, Y. Wang, B.O. Gunderman, A. Qiu, M. Azizkhani, J. Sommer, Y. Chen, "Kinetostatics and Retention Force Analysis of Soft Robot Grippers With External Tendon Routing," *IEEE Robotics and Automation Letters*, vol. 10, no. 2, pp. 2064-2071, Feb. 2025.

5. M. Hrovat, A. Kolandaivelu, Y. Wang, A. Gunderman, H.R. Halperin, Y. Chen, and E.J. Schmidt, "Balanced-force shim system for correcting magnetic-field inhomogeneities in the heart due to implanted cardioverter defibrillators," *Frontiers in Medicine*, 11:1225848.

6. Y. Wang, M. Hrovat, A. Kolandaivelu, A. L. Gunderman, H. R. Halperin, E. J. Schmidt, and Y. Chen, "MR-Safe Cartesian Platform for Active Cardiac Shimming: Preliminary Validation," *IEEE Transactions on Biomedical Engineering*, vol. 71, no. 7, pp. 2131-2142, July 2024.

7. M. Hrovat, Y. Wang, A. Gunderman, H.R. Halperin, Y. Chen, E.J. Schmidt, and A. Kolandaivelu, "Abstract 13253: Remotely-Controlled Cantilevered Cardiac Shim Coil (CSS) Corrects Cardiac MRI Magnetic-Field Inhomogeneities Due to Implanted Cardioverter Defibrillators (ICDs): Preclinical Validation," *Circulation*, vol. 148, no. Suppl_1, A13253-A13253, 2023.

8. J. Shen*, Y. Wang*, M. Azizkhani, D. Qiu and Y. Chen, "Concentric Tube Robot Redundancy Resolution via Velocity/Compliance Manipulability Optimization," *IEEE Robotics and Automation Letters*, vol. 8, no. 11, pp. 7495-7502, Nov. 2023.

9. Z. Wu, C. Zhu, Y. Ding, Y. Wang, B. Xu, K. Xu, "A robotic surgical tool with continuum wrist, kinematically optimized curved stem, and collision avoidance kinematics for single port procedure," *Mechanism and Machine Theory*, vol. 173, 104863, 2022.

10. Y. Wang, Z. Wu, L. Wang, B. Feng, and K. Xu, "Inverse Kinematics and Dexterous Workspace Formulation for 2-Segment Continuum Robots With Inextensible Segments," *IEEE Robotics and Automation Letters*, vol. 7, no. 1, pp. 510-517, Jan. 2022.

Conference Papers

1. Y. Wang and Y. Chen, "Quasi-static Path Planning for Continuum Robots By Sampling on Implicit Manifold," *IEEE International Conference on Robotics and Automation (ICRA)*, Yokohama, Japan, 2024, pp. 8728-8734.

2. Y. Wang, Z. Qiu, J. Tokuda, E. J. Schmidt, A. Kolandaivelu, and Y. Chen, "MR-Conditional Robotic Actuation of Concentric Tendon-Driven Cardiac Catheters," *International Symposium on Medical Robotics (ISMR)*, Atlanta, GA, USA, 2024.

3. Y. Wang, Y. Zheng, L. Wang, B. Xu, and K. Xu, "Manipulability-Oriented Configuration Transition Control of Continuum Surgical Manipulators Based on Velocity Polytopes," *2021 IEEE International Conference on Robotics and Biomimetics (ROBIO)*, pp. 533–538, 2021.

4. Y. Wang, C. Zhu, Y. Ding, B. Feng, and K. Xu, "Feedforward Neural Network Assisted Configuration Transition Control of Continuum Surgical Manipulators," *2021 27th International Conference on Mechatronics and Machine Vision in Practice (M2VIP)*, pp. 617–622, 2021.

Technical Skills

Programming	C++, Python, MATLAB
Robotics	ROS2, SOFA, CasADi, GTSAM, motion planning, Bayesian estimation, Kalman filtering, control, system identification
Modeling	Cosserat rods, continuum mechanics, kinematics/dynamics, Lie groups, model order reduction
Machine Learning	PyTorch, Gaussian processes, neural networks, residual learning, physics-informed learning, meta-learning, reinforcement learning
Hardware	SolidWorks, CATIA, Siemens NX, 3D printing, motors/encoders, embedded systems, robotic system integration, medical catheter design & fabrication
Natural Languages	Chinese (native), English (fluent), Japanese (JLPT N1)

Awards and Honors

- Toppings fellowship, George W. Woodruff School of Mechanical Engineering, 2025
- Outstanding Graduate Award, Shanghai Jiao Tong University, 2022
- H&H Medical Scholarship, Shanghai Jiao Tong University, 2021
- Satake Scholarship, Shanghai Jiao Tong University, 2018
- Recognition award (team), Formula Student China (Combustion), 2017 & 2018
- Academic Excellence Scholarship, Shanghai Jiao Tong University, 2016 & 2017

Professional Service

- Reviewer: IEEE RA-L, IEEE T-MRB, IJRR, ISMR

References

Available upon request.