Ran ZHOU

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Education

Tsinghua University - Institute of Mechatronic Engineering Beijing, China
Ph.D. in Mechanical Engineering; GPA: 3.91/4.0 *Aug. 2020 - expected Jun. 2025*

- ***Ph.D. Supervisor:*** *Chuxiong HU (Associate Professor)*
- ***Research Field:*** *Precision/Ultra-Precision Mechatronic Motion Control*
- ***Core Courses:*** *Introduction to Modern Control Theories and Methods, Advanced Numerical Analysis, Mechatronic Intelligent Control Engineering, Modern Mechatronics System*

Tsinghua University - Department of Mechanical Engineering Beijing, China
Bachelor in Mechanical Engineering; GPA: 3.87/4.0; Rank: ***1/109*** *Aug. 2016 - Jun. 2020*

- ***Core Courses:*** *Linear Algebra, Calculus, Theoretical Mechanics, Fluid Mechanics, Strength of Material, Electrical Engineering and Electronics, The Fundamental of Computer: The Hardware/Software Interface, Fundamentals of Machine Design, Basis of Control Engineering, Fundamentals of Manufacturing Engineering, Measurement and Test Technology, Numerical Control Technology, Robotic Technology and Application, Information Technology of Manufacturing Engineering*

Tsinghua University - Department of Computer Science and Engineering Beijing, China
Minor in Computer Application; GPA: 3.40/4.0 *Sep. 2017 - Jun. 2020*

- ***Core Courses:*** *C++ Programming, JAVA and Object-Oriented Programming, Data Structure, Introduction of Artificial Intelligence, Modern Operating Systems, Discrete Mathematics in Computer Science A, Computer Organization and Architecture, Software Engineering*

Research and Projects

Real-Time Iterative Compensation Framework for Precision Motion System

- Proposed a novel real-time iterative compensation (RIC) framework to overcome the limitation of robustness to trajectory variations and external disturbances in offline feedforward strategies such as iterative learning control (ILC).
- Performed the comprehensive theoretical analysis and mathematical proof in the aspect of real-time prediction accuracy, iteration convergence, unbiased parameter estimation, and stability condition.
- Conducted simulation investigations in MATLAB/Simulink. Comparative results proved that the proposed RIC framework possessed satisfactory dynamic regulation capability, which contributed to high tracking accuracy comparable to ILC or even better and strong robustness to trajectory variations and external disturbances.

Nonlinearity Compensation and High-Frequency Flexibility Suppression Based RIC Method

- Developed a nonlinearity compensation and high-frequency flexibility suppression scheme. The unexpected nonlinearity and high-frequency flexible mode of the plant, which may limit the achievable control performance, was first suppressed.
- Synthesized the proposed RIC method with the nonlinearity compensation and high-frequency flexibility suppression mechanism to further reduce the tracking error of precision motion systems.
- Built a full-closed loop ball-screw-driven motion stage as the testbed and conducted comparative tracking experiments. The proposed method achieved the same high tracking accuracy as ILC, while it significantly outperformed ILC in the aspect of trajectory generalization and disturbance rejection.

Intelligent GRU-RIC Feedforward Compensation Control for Ultra-Precision Motion Stage

- Constructed a gated recurrent unit (GRU) neural network to precisely predict the tracking error before practical tracking implementation. The predicted tracking error was utilized as a position-loop feedforward compensation term.
- Extended RIC method to ultra-precision motion systems represented by friction-free levitated linear or planar motors.
- Proposed an intelligent GRU-RIC feedforward compensation control method with application to an ultra-precision motion stage. The offline compensation term by GRU prominently reduced the tracking error without changing feedback stability while the online compensation term by RIC further enhanced the tracking accuracy and the disturbance rejection ability.

- Built a nano-precision air-bearing motion stage as a testbed. For various trajectories, GRU-RIC practically reached 10-nm tracking accuracy under 100-mm motion stroke with great trajectory generalization and strong robustness.

Ultra-Precision Drive and Control of Long-Stroke Magnetically Levitated Planar Motor

- Participated in the research project supported by the National Natural Science Foundation.
- Assisted in building and integrating the hardware of an ultra-precision maglev planar motor prototype.
- Embedded the multi-degree-of-freedom drive and control algorithms of the maglev planar motor in WindRiver VxWorks real-time operation system. Contributed to achieving nm-level motion accuracy under hundred-mm-level motion stroke.

Publications

[1] **R. Zhou**, C. Hu, Z. Wang, S. He, and Y. Zhu, "Nonlinearity Compensation and High-Frequency Flexibility Suppression Based RIC Method for Precision Motion Control Systems," *IEEE Trans. Ind. Informat.*, vol. 19, no. 2, pp. 1332-1342, Feb. 2023.

[2] C. Hu, **R. Zhou**, Z. Wang, Y. Zhu, and M. Tomizuka, "Real-Time Iterative Compensation Framework for Precision Mechatronic Motion Control Systems," *IEEE/CAA J. Autom. Sinica*, vol. 9, no. 7, pp. 1218–1232, Jul. 2022.

[3] **R. Zhou**, C. Hu, B. Hou, and Y. Zhu, "Comparative Study of Performance-Oriented Feedforward Compensation Strategies for Precision Mechatronic Motion Systems," *IEEE Access*, vol. 10, pp. 100812-100823, 2022.

[4] Z. Wang, **R. Zhou**, C. Hu, and Y. Zhu, "Real-Time Iterative Compensation Based Contouring Control Method for Polar Coordinate Motion Systems," *IEEE/ASME Trans. Mechatron.*, vol. 27, no. 5, pp. 3517-3526, Oct. 2022.

[5] Z. Wang, **R. Zhou**, C. Hu, and Y. Zhu, "Online Iterative Learning Compensation Method Based on Model Prediction for Trajectory Tracking Control Systems," *IEEE Trans. Ind. Informat.*, vol. 18, no. 1, pp. 415–425, Jan. 2022.

[6] S. Wu, C. Hu, Z. Zhao, **R. Zhou**, and Y. Zhu, "A Novel Flux Estimator Using α-β Orthogonality Drift Elimination for High Performance Full-Speed-Range Sensorless Control," in *IEEE/ASME AIM*, Jul. 2022, pp. 1315–1320.

[7] Z. Wang, **R. Zhou**, C. Hu, and Y. Zhu, "Precision RIC Contouring Control Method for Polar Coordinate Motion Systems," in *IEEE RCAR*, Jul. 2021, pp. 744–749.

[8] **R. Zhou**, C. Hu, Y. Zhu, and M. Zhang, "Model Prediction based Online Feedforward Compensation Control of Maglev Planar Motor with Comparative Investigation," in *IEEE ICM*, 2021. **(Oral Report)**

Honors and Awards

- National Scholarship for Postgraduates (Top 2%) - Dec. 2022
- Second Prize in National College Mechanical Innovation Competetion - Oct. 2020
- First Prize in Beijing College Mechanical Innovation Competetion - Sep. 2020
- Tsinghua Future Scholar Scholarship - Aug. 2020
- Tsinghua Outstanding Undergraduate Award (Top 2%) - Jun. 2020
- Beijing Outstanding Undergraduate Award (Top 5%) - Jun. 2020
- National Scholarship for Undergraduates (Top 2%) - Dec. 2019
- Tsinghua Top Grade Scholarship for Undergraduates (**The highest student honor** with 10 winners per year in Tsinghua University) - Dec. 2019
- Tsinghua Comprehensive Excellence Award (Top 7%) - Dec. 2019
- Tsinghua Jiang Nanxiang Scholarship - Dec. 2018
- Tsinghua Comprehensive Excellence Award (Top 7%) - Dec. 2018
- Tsinghua Comprehensive Excellence Award (Top 7%) - Dec. 2017

Technical Skills and Interests

- **Services** Reviewer for *IEEE/ASME Transactions on Mechatronics*, *Ocean Engineering*
- **Languages** English(CET-6: 567/710, CET-4: 650/710), Chinese(Native)
- **Tools** MATLAB/Simulink, dSPACE, VxWorks, AutoCAD, SolidWorks, Python, C/C++, LaTeX
- **Activities** Volunteer of 2022 Beijing Winter Olympics, Undergraduate Counselor of Grade 2020 in THU
- **Specialty** Table Tennis (1st in Men's Team, 3rd in Men's Doubles at Beijing College Table Tennis Games)