Kunzhao Ren

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[Personal Website]

EDUCATION BACKGROUND

University of Wisconsin-Madison Madison, WI
Mechanical Engineering, Ph.D. Student, GPA 3.75 Aug 2025 – Present

Zhejiang University Hangzhou, Zhejiang
Electronic Information, Master of Engineering Sep 2022 – Jun 2025

Xi'an Jiaotong University Xi'an, Shaanxi
Electrical Engineering and Automation, Bachelor of Engineering, GPA 3.89 (90.78) Aug 2017 – Jul 2022

Tianjin Nankai High School Tianjin
Preparatory Program in the Honors Youth Program, Xi'an Jiaotong University Aug 2016 – Jun 2017

RESEARCH INTERESTS

Legged Robots, Model Predictive Control, Reinforcement Learning, Whole Body Control, Robotic World Model.

PUBLICATIONS

[1] J. Kang, **K. Ren**, Tao Pang, and X. Xiong. "PRIME: Physically-consistent Robotic Inertial and Motion Estimation for Legged and Humanoid Robots." Submitted to *Robotics: Science and Systems*, 2026. [Video]

[2] S. Shin, **K. Ren**, X. Xiong, and J. Hanna. "Articulated-Body Dynamics Network: Dynamics-Grounded Prior for Robot Learning." Submitted to *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2026. [Video]

[3] H. Wang, Q. Liao, B. Zhang, **K. Ren**, K. Sreenath, and X. Xiong. "SPARK: Skeleton-Parameter Aligned Retargeting on Humanoid Robots with Kinodynamic Trajectory Optimization." Submitted to *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2026. [Video]

[4] R. G. Paiva, C. Ho, J. Kang, **K. Ren**, X. Xu, and X. Xiong. "DASH Robot: Minimalistic Design and Optimal Aerial-Terrestrial Locomotion via Contact-Implicit Control." Submitted to *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2026. [Video]

[5] **K. Ren**, C. Tian, S. Chen, D. Zheng, and Y. Liu. "An Analysis of Jumping Control Planning and Simulation for Quadruped Robots." *Technology Innovation and Application*, vol. 11, no. 17, pp. 1–8, 2021. (in Chinese)

PATENTS

[1] Q. Zhu, **K. Ren**, Y. Yu, Y. Shen, Z. Yin, and J. Wu. "A Closed-Form Method for Solving the Inverse Kinematics of a Six-DOF Multi-Link Mechanism" (English translation). *China Patent Application* CN120386962A, under substantive examination since Aug. 15, 2025.

[2] Q. Zhu, **K. Ren**, J. Wu, and R. Xiong. "A Model Reference Adaptive Control-Based Variable-Load Standing Method for Humanoid Robots" (English translation). *China Invention Patent* CN115616898B, granted Feb. 14, 2025.

RESEARCH EXPERIENCE

Perception-Aware Multi-Terrain Humanoid Walking via Nonlinear MPC Oct 2023 – Jun 2025
Zhejiang University, advisor: Qiuguo Zhu Hangzhou, Zhejiang

- Developed an **nonlinear MPC planner** for **perception-aware multi-terrain humanoid walking** based on **OCS2**, using a **centroidal dynamics model** that incorporates **joint positions and velocities** to account for limb dynamics and foothold region constraints, and replanning at **100 Hz**.
- Enhanced the **integration of perception and control** by explicitly considering **foothold region constraints** in the planning process.
- To address the **computational complexity** of nonlinear MPC, developed a **task-space QP-based whole-body control strategy** that enabled **1 kHz torque-based whole-body control**.

- Validated the approach in **RaiSim simulations** and on the **Wukong-IV humanoid robot**, increasing maximum forward speed from **1.0 m/s to 1.7 m/s** and enabling traversal of **22° slopes** and **25 cm steps** in simulation.

Stable Multi-Terrain Humanoid Walking via Convex MPC Jan 2023 – Oct 2023

Zhejiang University, advisor: Qiuguo Zhu Hangzhou, Zhejiang

- Developed a **convex MPC-based motion control framework** for **stable multi-terrain humanoid walking** based on **Cheetah-Software**, using **single rigid body dynamics model** and computing **ground reaction force** for the stance leg at **200 Hz**.
- Implemented **heuristic foothold planning**, **cosine swing-leg trajectories**, and **linear Kalman filter-based state estimation**.
- Enabled stable **multi-terrain walking** on tiles, soil, asphalt, and grass with **ground contact detection**.
- Validated robustness against **external disturbances** including pushes, kicks, steel pipes, speed bumps, and curbs.

- The system was **showcased at the 19th Asian Games Hangzhou** and **demonstrated to visiting dignitaries and senior officials**. [Video]

HONORS AND AWARDS

Outstanding Graduate, Xi'an Jiaotong University	Jun 2022
First Prize, Quadruped Event, China University Robot Competition	Jul 2021
Third Prize, "Throwing arrows into pots", China University Robot Competition	Jul 2021
Ultra-High-Voltage Scholarship, 5/350	Dec 2020
First Prize, "ROBO RUGBY 7s", China University Robot Competition	Oct 2020
First Prize, Quadruped Simulation Event, China University Robot Competition	Aug 2020
Second Prize, Shaanxi Division, Contemporary Undergraduate Mathematical Contest in Modeling	Dec 2019
Outstanding Student, Xi'an Jiaotong University	Nov 2019
Second-Class Scholarship, Xi'an Jiaotong University	Nov 2019

SKILLS

Languages: Mandarin (Native), English (TOEFL 102)
Programming: C++, Python, Matlab
Robotics: ROS/ROS2, Pinocchio
Simulation: MuJoCo, Isaac Gym/Sim, RaiSim
Hardware: Unitree Go2/G1, WukongIV Humanoid Robot
Engineering: Linux/Ubuntu, Git/GitHub, Docker