Shijiang Li (李仕江), Ph.D. Student

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Research Interests

- Physics-informed data-driven modeling and control of robotic systems interacting with complex environments.
- Multi-sensor fusion, perception, and digital twin technologies for field and construction robotics.

Education

- **Ph.D. in Mechanical Manufacturing and Automation, Xiamen University, China**
  2021.09 – present

Dissertation: Research and Application of Data-Driven Modeling of the Coupling Relationship Between Excavation Robot Buckets and Materials

- **B.Eng. in Mechanical Design & Manufacturing and Automation, Xiamen University, China**
  2017.09 - 2021.06

GPA: 3.6/4; Ran: 3/61

Selected Project Experience

- **Research and Application of Data-Driven Modeling of the Coupling Relationship Between Excavation Robot Buckets and Materials** **2023.03 – present**

Participated in the development of a physics-informed data-driven framework to model the coupling mechanisms between excavation robot buckets and heterogeneous materials such as sand, gravel, and loose soil. Designed and implemented a multi-sensor acquisition system integrating stereo vision, force sensing, and kinematic monitoring to capture bucket–material interaction dynamics. Applied deep learning algorithms combined with physics-based constraints to predict excavation resistance and bucket fill rate under varying conditions. The model was further used for trajectory optimization to balance energy efficiency, operational time, and material handling performance.

- **Development of an Electric Micro-Excavator and Its Digital Twin System** **2021.09 - 2023.07**

Mainly responsible for the design and development of an electric micro-excavator, covering mechanical, hydraulic, and electrical systems, achieving fully electric drive and remote control functions. Developed a real-time digital twin system integrating multi-sensor data fusion, 3D kinematic modeling, and cloud-based monitoring, ensuring synchronization between the physical machine and its virtual model. Enabled remote operation and performance optimization through bidirectional interaction between the excavator and its digital counterpart. The system improved operational safety, reduced maintenance costs, and provided a scalable platform for intelligent excavation research and industrial applications.

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Skill and Abilities

- **Research and Analysis:** Involved in studies on physics-informed data-driven modeling, intelligent control, and optimization for construction machinery, with experience in analyzing coupling mechanisms between mechanical systems and materials.
- **Data Science and AI:** Experienced in applying deep learning, machine learning, and multi-sensor data fusion to develop predictive models for time-series data under varying operational conditions.
- **System Development:** Participated in the design and integration of mechanical, hydraulic, and electrical systems for robotic and mechatronic applications, including electric micro-excavators.
- **Simulation and Modeling:** Developed and applied dynamic system simulations, 3D kinematic models, and digital twin systems for monitoring, diagnosis, and performance assessment.
- **Programming and Tools:** Python, MATLAB, C++; familiar with ROS, PyTorch, SolidWorks, AutoCAD.
- **Communication and Collaboration:** Contributed to academic publications, conference presentations, and joint research with industrial partners.

Selected Publications

1. **S. Li**, G. Zhou, S. Wang, X. Jia, L. Hou, Multi-sensor data fusion and deep learning-based prediction of excavator bucket fill rates, Automation in Construction 171 (2025), https://doi.org/10.1016/j.autcon.2025.106008.
2. **S. Li**, S. Wang, X. Chen, G. Zhou, B. Wu, L. Hou, Application of physics-informed machine learning for excavator working resistance modeling, Mechanical Systems and Signal Processing 209 (2024) 111117, https://doi.org/10.1016/j.ymssp.2024.111117.
3. **S. Li**, S. Wang, X. Chen, G. Zhou, L. Hou, Identification of material excavation difficulty and uncertainty analysis based on Bayesian deep learning, Journal of Industrial Information Integration 42 (2024) 100728, https://doi.org/10.1016/j.jii.2024.100728.
4. **S. L**i, L. Hou, Z. Chen, S. Wang, X. Bu, Uncertainty modeling and applications for operating data-driven inverse design, Journal of Engineering Design 34 (2) (2023) 81-110, https://doi.org/10.1080/09544828.2023.2180846.
5. **S. Li**, G. Zhou, Y. Dang, X. Jia, S. Wang, L. Hou, Modeling of Excavator Bucket-Material Interaction Based on Multi-Task Learning. (Under Review)
6. **S. Li**, X. Zhou, S. Wang, Y. Pan, T. Guo, L. Hou, Excavation Trajectory Planning Based on Feedforward Neural Network and Physics-Encoded Optimization. (Under Review)

Awards

- China Association for Science and Technology (CAST) Young Talent Support Program, PhD Student Plan, China Association for Science and Technology, 2025.01
- Xiamen University Nanqiang Outstanding PhD Student Scholarship, Xiamen University, 2023.09