Zhen Fan

Email: e1373384@u.nus.edu Phone Number: (+86) 15315024480 / (+65) 85022154

Research Interests

Research explores the potential of **High-fidelity Digital Twins**, **Synthetic Data Generation**, and **Multimodal Cognitive Agents** to revolutionize **Embodied AI**, with a specific focus on bridging the gap between simulation and reality. Work focuses on leveraging physics-based simulation and knowledge-driven reasoning to develop data-efficient, context-aware, and trustworthy agentic systems for seamless **Human-Machine Collaboration**.

Education

- **National University of Singapore, NUS** — Singapore
  Master of Science (Mechanical Engineering) — *GPA: 4.45/5.0* — *2024 - 2025*
  - **Advisors:** Dr. Jerry Fuh Ying Shi, Dr. Wen Feng Lu, and Dr. Bingbing Li
  - **Research Field:** Digital Twins, Human-Centric & Smart Manufacturing, LLM, LLM Agents.
- **National University of Singapore Suzhou Research Institute, NUSRI** — Suzhou, China
  Exchange Student — *GPA: 85.95/100* — *2023 - 2024*
  - **Core Courses:** Fundamentals of Product Design & Development (89), Final Year Project/Bachelor's Thesis (88.22), Micro-systems Design & Applications (80.48).
- **Beijing Jiaotong University, BJTU** — Beijing, China
  Bachelor of Engineering (Mechatronics Engineering) — *GPA: 3.56/4.0* — *2020 - 2024*
  - **Core Courses:** Electronics (97), Engineering Physics (96), Embedded System & Applications (90), Mechanical Engineering Design (88), Robots & Flexible Automation (88), Signals & Systems (87), Circuits and Systems (86).

Research Experience

- **Digital Twin for Sim-to-Real Transfer & Robot Learning** — NUS, Singapore
  Simulation Engineer — *Oct 2024 – May 2025*
  - Engineered a high-fidelity Digital Twin (DT) system in NVIDIA Omniverse to address the critical data scarcity bottleneck, implementing an automated synthetic data generation workflow to scale training resources infinitely.
  - Established a robust Sim-to-Real pipeline that synthesizes photorealistic datasets with extensive domain randomization, effectively bridging the reality gap and eliminating the dependency on labor-intensive manual labeling.
  - Validated the engineering efficacy by achieving a 90% reduction in data acquisition timeline (30 h $\rightarrow$ 3 h) while maintaining 90.31% precision in real-world scenarios, proving the viability of simulation-driven development.
- **Application of Human-Centric DT and KG System in Advanced Manufacturing** — NUS, Singapore
  Core Researcher — *May 2024 – Jan 2025*
  - Collaborated with NVIDIA to architect a Human-Centric Knowledge System that automates the transformation of unstructured technical documentation into a structured Knowledge Graph, serving as the reliable "cognitive backend" for intelligent agents.
  - Built a closed-loop Mixed Reality ecosystem that not only guides operators but actively captures and digitizes implicit expert knowledge, enabling the system to continuously learn from human expertise.
  - Demonstrated superior system robustness with a 336% improvement in global context understanding, establishing a new standard for reliable Human-Robot interaction in complex manufacturing tasks.
- **LLM-Driven Knowledge Extraction and Data Management** — NUSRI, Suzhou
  Final Year Project (NUSRI) — *Oct 2023 – May 2024*
  - Proposed and implemented an automated Named Entity Recognition framework for Additive Manufacturing, replacing manual taxonomy construction methods.
  - Leveraged Large Language Models (LLMs) with In-Context Learning to structure unstructured technical data, achieving an F1 score of 0.9192 and enhancing data connectivity for downstream intelligent agents.
- **Embedded Control Systems and Robotic Hardware Implementation** — BJTU, Beijing
  Undergraduate Innovation Projects — *Oct 2021 – Jul 2022*
  - Designed and assembled an STM32-based intelligent vehicle system. Developed C/C++ drivers for multi-sensor fusion and implemented PID control algorithms for precise real-time steering and velocity regulation.
  - Configured an ABB IRB-320 robotic arm integrated with laser rangefinders. Implemented a reverse modeling workflow by processing 3D point cloud data into high-accuracy surface models, validating trajectories in RobotStudio before physical deployment.

Publications

- **MetalMind: A Knowledge Graph-Driven Human-Centric Knowledge System for Metal Additive Manufacturing.** Fan, H., **Fan, Z.**, Liu, C., et al. npj Advanced Manufacturing, 2025. DOI: 10.1038/s44334-025-00038-9
- **Sim2Know: new paradigm of digital twins to design and inform human-centric knowledge system.** Li, B., Fan, H., **Fan, Z.**, Erkoyuncu, J. A., & Zhang, H. C. CIRP Annals (Top-tier conference in manufacturing), 2025. DOI: 10.1016/j.cirp.2025.04.028

Personal Skills

- **Artificial Intelligence and Simulation:** Proficient in NVIDIA Omniverse (Isaac Sim) for high-fidelity simulation and generating synthetic data for Self-Supervised Learning models. Skilled in developing Multimodal Agents using LLMs, Knowledge Graphs (Neo4j), and Retrieval-Augmented Generation (RAG) frameworks. Familiar with Unity 3D for XR prototyping.
- **Programming and Computational Tools:** Strong command of Python for AI development and C/C++ for embedded robot control; proficient with MATLAB for data analysis and Linux environments for system deployment. Experienced with Blender for 3D asset creation and Docker/Git for scalable project management.
- **Engineering and Hardware Implementation:** Solid background in Mechatronics with hands-on experience in STM32 microcontroller development (using Keil) and multi-sensor fusion. Proficient in CAD/CAE workflows using SolidWorks, AutoCAD, Inventor, and Ansys for mechanical design and simulation. Skilled in RobotStudio for robotic trajectory planning. Familiar with Additive Manufacturing operational logic (e.g., Renishaw AM400).
- **Languages:** English (Proficient, capable of academic writing), Chinese (Native).

Honors & Certifications

- NVIDIA Certified Associate – Generative AI and LLMs (Valid: 2025–2027) *Year 2025*
- Third-Class Academic Scholarship *Year 2023*
- Second Prize, University Student Innovation Competition (Top 15%) *Year 2022*
- Outstanding Student Leader, Beijing Jiaotong University *Year 2022-2023*