

Intelligent additive manufacturing: from multi-physics modeling to AI-driven prediction and diagnostics

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Abstract:

The wide applications of additive manufacturing are hindered by the lack of comprehensive understanding of process-structure-property relationships and intelligent optimization and control. To this end, we have been developing intelligent additive manufacturing, where digitalization is a key enabler. We start from multi-scale multi-physics modeling to understand the fundamental mechanisms, spanning from powder and melt pool dynamics, to microstructure and mechanical properties, i.e., process-structure-property relationships. To enhance the computational efficiency, we have developed physics-informed AI models using physics-based simulation results as the training data and physical laws as the constraints. To achieve rapid and comprehensive diagnostics to identify defects for further close-loop control, given that most sensor data only contains limited and indirect information, we leverage physics-based simulation and AI models to extract more in-depth and instructive information.

Bio:

Dr. Wentao Yan is an associate professor in the Department of Mechanical Engineering, National University of Singapore (NUS). Before joining NUS in 2018, Dr. Yan was a postdoctoral fellow at Northwestern University, Evanston. He received his Ph.D. degree jointly at Tsinghua University, Beijing and Northwestern University, and his bachelor's degree from Tsinghua University, Beijing in 2012. Supported by multi-million-dollar grants, his research group with 20+ students focus on multi-scale multi-physics modeling, experimental investigation and data analysis of additive manufacturing. Over 30 of his former postdocs and PhD students have got faculty positions. His team was the biggest winner consecutively in the 2022 and 2025 NIST AM-Bench Simulation Challenges, by winning 9 awards out of totally 40 in 2022 and 9 awards of totally 25 in 2025. He has won multiple best paper awards in various journals. He currently serves as the Senior Editor for Additive Manufacturing Journal, and an editorial board member for International Journal of Machine Tools and Manufacture, and a few others.



Monday, September 14, 2026 4:00 – 5:00 p.m.

1310 Yeh Student Center