

Digital Twin for Sustainable Manufacturing

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Abstract

A decade after the conceptualization of “digital twin” and the revival of artificial intelligence (AI) led by deep neural networks, the manufacturing industry is witnessing their accelerated convergence. Supported by the exponential growth of data arising from widespread deployment of sensors and the continued advancement of computational infrastructure, the advancement of AI technologies over the past decade have not only changed the way how a digital replica of a physical system in manufacturing can be created and updated that *looks* and *behaves* like its physical counterpart, but also new possibilities for the digital twin to *guide* the physical system towards optimized *design*, *operation*, and *control*. The result is improved functionality, productivity, and reliability of a new generation of products that directly contribute to sustainability in manufacturing. This keynote presents an overview of the digital twin technology and its representative applications in manufacturing. After introducing the basic building blocks of digital twin, examples of its applications to manufacturing are illustrated. The presentation demonstrates the potential of digital twin as a key enabler in integrating physical science with data science through a digital platform, to facilitate continued advancement of sustainable manufacturing.

Biographical Sketch



Robert Gao is the Cady Staley Professor of Engineering and Department Chair of Mechanical and Aerospace Engineering at Case Western Reserve University in Cleveland, Ohio. Since receiving his Ph.D. degree from the Technical University of Berlin, Germany in 1991, he has been working on physics-based signal transduction mechanisms, stochastic modeling, mechatronic system design, and AI/ML-based data analytics for improving the observability of cyber-physical systems such as manufacturing machines, with the goal to improve process and product quality control.

Professor Gao is a Fellow of the ASME, SME, IEEE, CIRP, and a Distinguished Fellow of the International Institute of Acoustics and Vibration (IIAV). He has published over 400 technical papers, including more than 190 journal articles, three books, and holds 13 patents. He has received several professional awards, including the ASME Milton C. Shaw Manufacturing Research Medal (2023), ASME Blackall Machine Tool and Gage Award (2018), SME Eli Whitney Productivity Award (2019), IEEE Instrumentation and Measurement Society Technical Award (2013), IEEE Best Application in Instrumental and Measurement Award (2019), Hideo Hanafusa Outstanding Investigator Award (2018), and several Best Paper awards. Prof. Gao is the Chair of the Scientific Committee of the North American Manufacturing Research Institute (NAMRI/SME) and Chair of the Collaborative Working Group on AI in Manufacturing (CWG-AI) of CIRP. He has served as an Associate Editor for several journals, and is currently a Senior Editor for the IEEE/ASME Transactions on Mechatronics.