Session on
Digital Twin Interdisciplinary Frontiers I (IF1)

Wednesday, October 16th 2024

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Milan Time	Beijing Time	Agendas
10:00	16:00	**IF1-1 Reinforcement Learning Enhanced Digital Twins for Smart Factory Scheduling** Yuqian LU
10:30	16:30	**IF1-2 Responsible AI Engineering & Digital Twin** Qinghua LU
11:00	17:00	**IF1-3 Digital twin for smart remanufacturing of high-value assets** Jun HUANG
11:30	17:30	**IF1-4 Modeling and Optimization of Manufacturing Service Collaboration Based on Digital Twins** Weihao XIE
12:00	18:00	**IF1-5 Interface physics and engineering of perovskite optoelectronic devices** Deying LUO
15:00	21:00	**IF1-6 An Enabling Digital Twin for Quality Control in Micro Electrical Discharge Machining** Long YE
15:30	21:30	**IF1-7 Advancing Towards Exascale: Creating Digital Twin Vascular Models for Hemodynamics** Xiao XUE
16:00	22:00	**IF1-8 Digitalization and automation of disassembly for industrial sustainability** Yongjing WANG
16:30	22:30	**IF1-9 Data-Driven Modeling of Digital Twins: Challenges and Opportunities** Paulo Victor LOPES, Giovanni LUGARESI, Rodolfo Pereira FRANKLIN, Filipe A. N. VERRI
17:00	23:00	**IF1-10 Digital twin-based multi-view energy efficiency prediction framework for machining systems** Zhongcheng FU

DT Interdisciplinary Frontiers Ⅰ （IF1)

Chair

Stefan PICKL

acatech Fellow,
Bundeswehr University Munich (Germany)

Co-Chair

Fei TAO

Professor,
Beihang University （China)

Yupeng WEI

Associate Professor,
Beihang University （China)

Marvin MAY

Chief Engineer,
University of Kaiserslautern-Landau (Germany)

DT Interdisciplinary Frontiers Ⅰ (IF1-1)

Yuqian LU

Senior Lecturer,
the University of Auckland (New zealand)

Title:
Reinforcement Learning Enhanced Digital Twins for Smart Factory Scheduling

Abstract

Real-world factories operate in a constant state of flux, facing unpredictable changes due to dynamic factors such as unexpected job order arrivals, diverse product ranges, urgent requests, machine breakdowns, and variable processing times. Consequently, effective optimal production scheduling presents a formidable challenge. This talk showcases the potential of smart digital twins enhanced by reinforcement learning technologies in addressing this complex problem. Our unique approach conceptualizes factory machines as independent smart digital twins, each equipped with its own scheduling policy learned through reinforcement learning technologies. Through unique reinforcement learning model design and a series of experiments, we demonstrate the efficacy of this method in tackling real-world scheduling challenges. Furthermore, our research reveals that incorporating engineering knowledge can significantly enhance the exploration of satisfactory scheduling policies, leading to more robust and efficient solutions for industrial applications.

DT Interdisciplinary Frontiers Ⅰ (IF1-2)

Qinghua LU

Principal research scientist,
CSIRO's Data61 (Australia)

Title:
Responsible AI Engineering & Digital Twin

Abstract

The rapid advancements in AI, particularly with the emergence of large language models (LLMs) and their diverse applications, have attracted huge global interest and raised significant concerns on responsible AI and AI safety. While LLMs are impressive examples of AI models, it is the compound AI systems, which integrate these models with other key components for functionality and quality/risk control, that are ultimately deployed and have real-world impact. These AI systems, especially autonomous LLM agents and those involving multi-agent interacting, require system-level engineering to ensure responsible AI and AI safety. On the other hand, data is the lifeblood of AI systems, cross-cutting different components in AI systems. In this talk, I will introduce a responsible AI engineering approach to address system-level responsible AI challenges. This includes engineering/governance methods, practices, tools, and platforms to ensure responsible AI and AI safety. Specially, I will talk about how digital twin can be integrated into responsible AI engineering.

DT Interdisciplinary Frontiers Ⅰ (IF1-3)

Jun HUANG

Professor,
Wuhan University of Technology (China)

Title:
Digital twin for smart remanufacturing of high-value assets

Abstract

Remanufacturing can give end-of-life products new life cycles and make them have the same quality and performance as new manufactured products, which has economic, resource, environmental and social benefits. Remanufacturing saves raw materials and energy and reduces greenhouse gas emissions as well as landfill requirements. Digital twin has been increasingly to be employed to reduce the impact of quantity, quality, and demand uncertainties in remanufacturing of high-value assets, enabling smart remanufacturing. This presentation will determine the functional requirements for a digital twin model fit for high-value asset remanufacturing. Disassembly is a critical step in remanufacturing. The research on robotic disassembly carried out in our lab will be introduced briefly.

DT Interdisciplinary Frontiers Ⅰ (IF1-4)

Weihao XIE

Postgraduate student,
Wuhan University of Science and Technology (China)

Title:
Modeling and Optimization of Manufacturing Service Collaboration Based on Digital Twins

Abstract

With the gradual interconnection and integration of manufacturing resources in the physical and virtual space, it has become an inevitable trend to establish the manufacturing service collaboration (MSC) mode of virtual and real fusion, which can meet the personalized and complex manufacturing requirements under the new situation. In order to realize this collaboration mode, how to develop from static service collaboration in virtual space to MSC under the fusion of virtual and real space is the key core. In this paper, a digital twin driven manufacturing service collaboration method (DT-MSC) is proposed to solve this problem. It discusses service collaboration description method combining static encapsulation and dynamic awareness, which describes and maps the static resources and dynamic states of manufacturing services. Then, it proposes the basic model of service collaboration by taking elements of virtual and real as the object, including physical object-physical object, physical object-virtual model and virtual model-virtual model. Besides, it designs a service collaboration monitoring mechanism containing multi-service information to improve the success rate of service collaboration. This method provides possibility for realizing the transformation from traditional MSC into digital twin MSC.

DT Interdisciplinary Frontiers Ⅰ (IF1-5)

Deying LUO

Postdoctoral Fellow,
the University of California San Diego (US)

Title:
Interface physics and engineering of perovskite optoelectronic devices

Abstract

Halide perovskite represents a promising new class of materials for the next generation of optoelectronic devices, spanning from solar cells to light-emitting diodes. However, achieving both high device efficiencies and stabilities faces sizable challenges due to non-ideal interface contacts. Therefore, developing rational strategies for engineering interfaces in perovskite optoelectronic devices plays a key role in enhancing overall performance. We conducted studies on the chemical reaction kinetics involved in surface passivation of halide perovskite semiconductors, and elucidated fundamental physical principles dictating band alignment at perovskite/organic interfaces. Upon a deeper understanding of interface physics in perovskite optoelectronic devices, we devised effective approaches to tackle interface-related issues that impede device performance improvement, resulting in improved device performance and the realization of all-in-one perovskite devices. Lastly, we introduced an amorphous rare metal oxide (YbOx) buffer layer, considerably boosting device efficiencies and stabilities of inverted perovskite solar cells.

DT Interdisciplinary Frontiers Ⅰ (IF1-6)

Long YE

Research Associate,
the University of Edinburgh (UK)

Title:
An Enabling Digital Twin for Quality Control in Micro Electrical Discharge Machining

Abstract

Micro electrical discharge machining (µEDM) is a vital technique for producing miniaturized components, renowned for its ability to process challenging materials such as superalloys and technical ceramics, irrespective of their mechanical properties. However, the intricate spatio-temporal process phenomena involved in µEDM pose significant challenges in understanding the material removal mechanisms, complicating the assurance of component quality, particularly for intricate geometries or mass production. This research addresses these challenges by developing a two-level digital twin (DT) framework for on-line µEDM process and quality management. The first-level DT focuses on the discharge process, utilizing a hierarchical deep learning model to detect anomalies and a real-time feedback controller to maintain the discharge stability. The second-level DT handles digital quality management, employing a transfer learning model to predict quality across varying energy regimes and material types, combined with a path-dependent compensation strategy for layer-by-layer quality correction. The proposed DT framework is demonstrated in an industrially relevant case study, generating contour-parallel defects on a bearing inner ring, showcasing its potential for enhancing µEDM process control and product quality.

DT Interdisciplinary Frontiers Ⅰ (IF1-7)

Xiao XUE

Research Fellow,
University College London (UK)

Title:
Advancing Towards Exascale: Creating Digital Twin Vascular Models for Hemodynamics

Abstract

As the global population ages, there is increasing focus on health and well-being. Understanding and predicting the impact of dis eases is crucial for advancing digital twin healthcare. In an era of rapidly growing computational power, driven by advances in CPU and GPU technologies, we are entering the exascale computing era. This offers a unique opportunity to use computational and physical modeling to deepen our understanding of vascular changes and pre-surgeon planning. In this presentation, we will explore the latest developments in simulating the human vascular system using the Lattice Boltzmann Method. The discussion will include a basic overview of the Boltzmann frame work and demonstrate its application in studying the flow through the Circle of Willis (CoW) in the brain. We will also examine how aortic stenosis affects blood pressure and identify key factors influencing the risk, growth, and rupture of abdominal aortic aneurysms (AAA). Additionally, we will introduce a method for integrating heart models with the thoracic aorta. This integration represents a significant shift towards high-fidelity, full-body 3D modeling in digital twin healthcare, opening up new research opportunities

DT Interdisciplinary Frontiers Ⅰ (IF1-8)

Yongjing WANG

Associate Professor,
the University of Birmingham (UK)

Title:
Digitalization and automation of disassembly for industrial sustainability

Abstract

Disassembly is a key step in remanufacturing and recycling, both of which are critical components in a circular economy. Disassembly is also a common operation in the repair and maintenance of machines and public infrastructure facilities (e.g. transport and energy). In many ways, disassembly is challenging to robotize due to variability in the condition of the returned products and the required dexterity in robotic manipulations. This talk introduces recent research developments in the area of robotic disassembly and remanufacturing automation at the University of Birmingham, and highlight key opportunities and technical gaps in the use of digitalization and automation to support sustainable manufacturing.

DT Interdisciplinary Frontiers Ⅰ (IF1-9)

Paulo Victor LOPES

PhD candidate,
Instituto Tecnológico de Aeronáutica (Brazil)

Title:
Data-Driven Modeling of Digital Twins: Challenges and Opportunities

Abstract

Digital Twins (DTs) provide a suitable solution for manufacturing systems analysis by simulating disruptive scenarios for better decision-making, though their complexity and constant updates remain challenging. Data-Driven Modeling of Digital Twins (D3T) emerges as a promising approach to automate the discovery and updating of these models. This work addresses three key gaps in D3T implementation: data collection, model discovery/validation, and what-if scenario analysis. Finally, proposing the use of artificial data generation, process mining, and automatic simulation techniques to benefit manufacturing systems.

DT Interdisciplinary Frontiers Ⅰ (IF1-10)

Zhongcheng FU

Ph.D student,
Wuhan University of Science and Technology (China)

Title:
Digital twin-based multi-view energy efficiency prediction framework for machining systems

Abstract

Large and extensive manufacturing systems consume a large proportion of manufacturing energy. Energy efficiency prediction is the premise of energy efficiency management. Most of the current energy efficiency forecasts are inferential forecasts based on historical data and empirical models, and once the processing environment changes, the forecast accuracy will be difficult to guarantee effectively. With the background of digital twin technology, a framework for multi-view energy efficiency prediction of machining systems is designed, the key technologies for achieving multi-view energy efficiency prediction are described, and the multi-view energy efficiency prediction method is explored. A multi-view energy-efficiency prediction platform based on digital twin technology is built, and experimental analysis of multi-view energy-efficiency prediction is conducted on the platform, and the results show that the proposed method is effective. The proposed multi-view energy efficiency prediction framework can provide theoretical and practical methodological support for green and intelligent manufacturing, and has important theoretical research and application value.