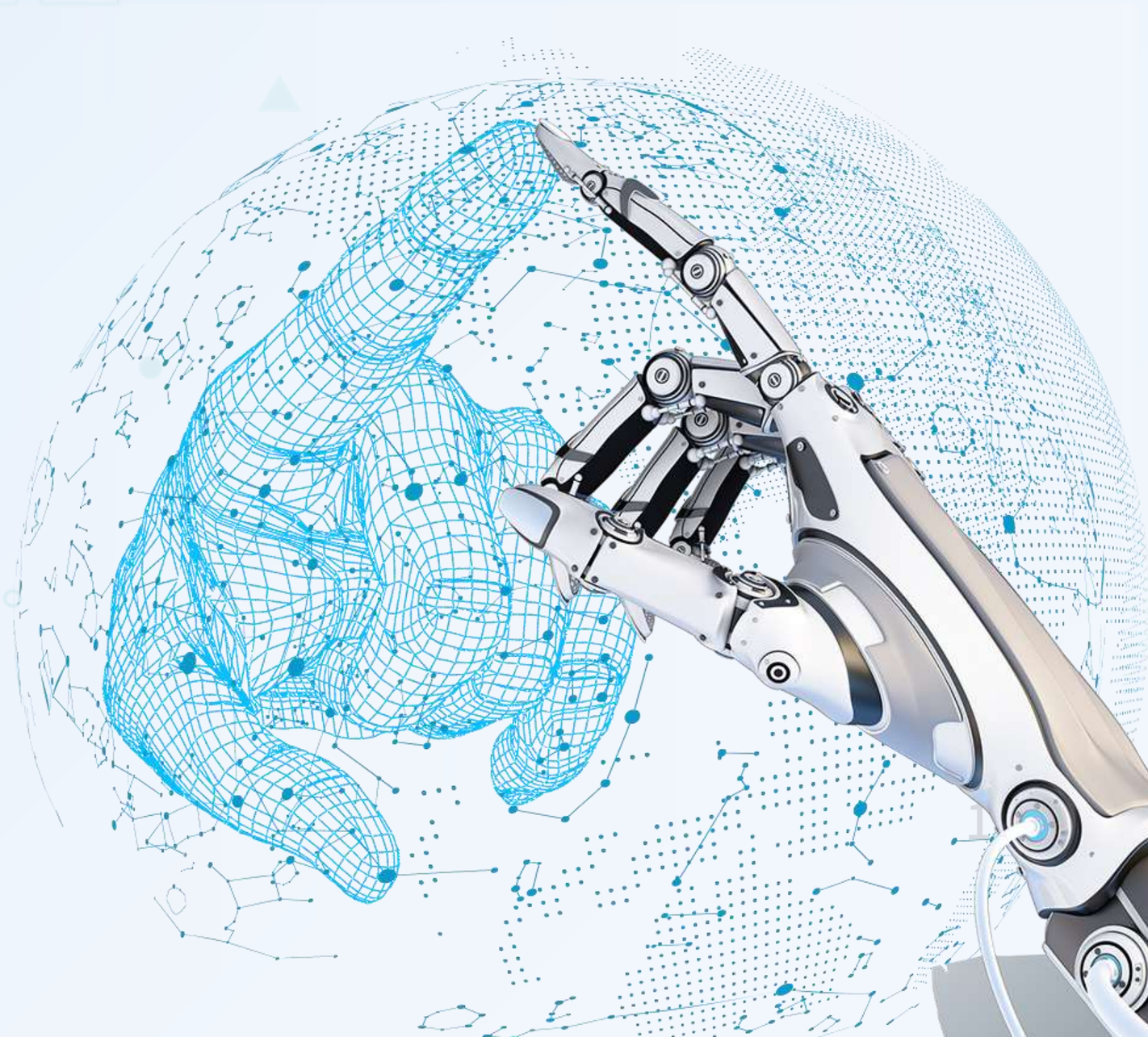
Make More Digital Twins

DigiTwin 2024 Program

The 4th Digital Twin International Conference

14th-18th October, 2024

Milan, Italy



CONTENTS

03 Welcome

04 Acknowledgement

05 The Digital Twin International Advisory Committee (DTIAC)

11 Organizing Committee

13 Additional Information

15 General Program

17 Opening Ceremony

18 Awards and Closing Ceremony

19 Keynotes

29 Sessions

Welcome





Dear Distinguished Guests, Colleagues, and Friends,

On behalf of the Digital Twin International Scientific Committee (DTIAC) and the Conference Organizing Committee, we would like to extend our warmest welcome and most sincere thanks to all of you to participate in the 4th Digital Twin International Conference (DigiTwin 2024).

Digital twin, as an important force for social progress and industrial transformation, is changing our world at an unprecedented rate. By deeply integrating the physical world with the digital world, digital twin brings revolutionary changes to many fields such as smart manufacturing, smart cities, aerospace, and healthcare. In this process, digital twin not only improves the efficiency of decision-making, optimizes the allocation of resources, but also promotes the innovation and upgrading of the industrial mode. In this era full of innovation and change, digital twin not only represents the forefront of scientific and technological innovation, but also indicates the infinite possibilities of future life.

Digital Twin International Conference (DigiTwin) aims to provide a high-end, open and cooperative exchange international platform for scientists, researchers, engineers, students, and beyond to jointly discuss the latest progress, research findings, industrial applications challenges and opportunities on digital twin. It is our belief that through in-depth exchanges and collisions, we will be able to stimulate more sparks of innovation, and promote digital twin to a higher level and a wider field. The theme of DigiTwin 2024 is "Make more Digital Twins". It is our hope that you will actively participate in the discussion and share your insights and ideas. Let us work together to promote more innovation and development of digital twins.

The initial idea of this international conference was proposed by Prof. Fei Tao in 2018. The 1st Digital Twin International Conference (DigiTwin 2021) was held in China, followed by DigiTwin 2022 in Australia, DigiTwin 2023 in France, DigiTwin 2024 in Italy. It is our goal to sustain this conference for more decades to come.

Many thanks to the strong support of all colleagues, especially the Chairs of the scientific sessions, we are able to put together a holistic conference program of 8 keynote speeches, 22 scientific sessions, 196 presentations, and multiple awards. The DigiTwin 2024 program covers a wide spectrum of topics on different facets of digital twin. Over 2200 participants from all over the world have registered the conference. We hope that the conference will build an international platform for the promotion of international collaboration on digital twin.

We are most grateful for the strong support from the Politecnico di Milano, International Institute for Interdisciplinary and Frontiers of Beihang University, Taylor & Francis, and all conference sponsors. In particular, we would like to extend special thanks to Profs. Tianliang Hu, Xiaojun Liu, and Lena Liu who have devoted tremendous efforts to conference organization.

To conclude, we wish the conference a great success and we wish every colleague good health. If you have any suggestions on how to make the conference a better one, please don't hesitate to let us know.

Andrea Matta and Fei Tao

General Chairs of the 4th Digital Twin International Conference (DigiTwin 2024)

Milano and Beijing, September 30th, 2024

Acknowledgement

We would like to extend our most sincere thanks to all members of the organizing committee, the Digital Twin International Advisory Board, and volunteers for their support, without which, DigiTwin 2024 would not have been possible.

Furthermore, we are most grateful for the generous and continued support from all the sponsors.

Organizers

- Politecnico di Milano, Italy
- Digital Twin (https://digitaltwin1.org)
- Taylor & Francis Group

Co-Organizer

- Digital Twin International Research Center, Beihang University

Sponsors



The Digital Twin International Advisory Committee

Based upon Digital Twin (*https://digitaltwin1.org/*), this conference is organized under the scientific guidance of the Digital Twin International Advisory Committee (DTIAC)(*https://digitaltwin1.org/advisors/*). The DTIAC is composed of 97 world-renowned domain experts who are advisors and ambassadors of Digital Twin.

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- Qinping Zhao, Beihang University, China

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Guidance for Using Tencent Meeting (VooV Meeting) Client

1. Download the Tencent Meeting (or VooV Meeting) Client

- **For Users in Mainland China:**

Please use the Tencent Meeting Client. Visit *https://meeting.tencent.com/download/* and select the appropriate version based on your device's operating system.

- **For Users Outside Mainland China:**

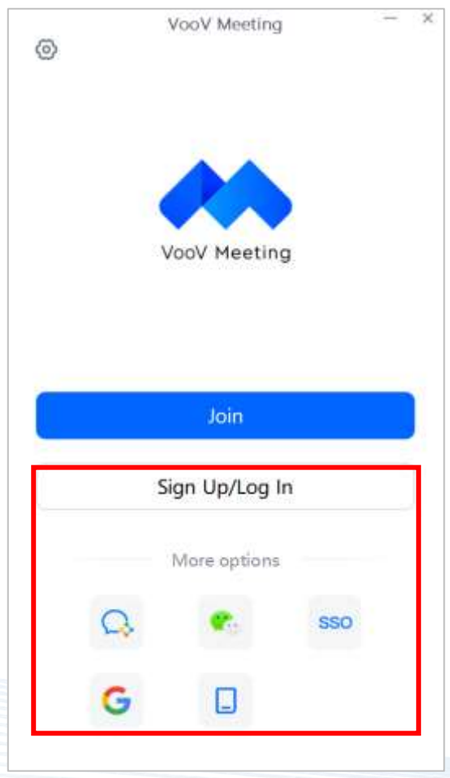
Please use the VooV Meeting Client. Visit *https://voovmeeting.com/download-center.html?from=1002* and choose the suitable version according to your device's specifications.

2. Sign Up and Log In:

- If you do not possess an account yet, you will be required to register by furnishing your email address, phone number, or any other necessary details.
- Once your account is established, you may proceed to log in using your login credentials to gain access to the meeting client.
- Using the provided meeting ID, you can then access the DigiTwin 2024 online conference.



Tencent Meeting Client Page



VooV Meeting Client Page

Additional Information

1. Secretary Contact

If you have any questions about conference logistics, please feel free to contact us.

Lena Liu (China) : *digitaltwin@buaa.edu.cn*

2. Website

The complete conference program, together with additional information, can be found on the conference websites as follows.

http://www.dtiac.com/

3. Call for Papers

The conference participants are welcomed to submit manuscripts to the open-access journal, Digital Twin, at *https://digitaltwin1.org/*. More information about Digital Twin, especially regarding the submission procedure, can be found at *https://digitaltwin1.org/for-authors/article-guidelines*. The articles will be published online with a valid DOI at the soonest 14 days since submission, followed by open peer review.

Time Zone Conversion Table

Paris Time(CET)	Beijing Time	London Summer Time	Delhi Time	Sydney Time	Wellington Time	Seattle Time	New York Time
9:00-9:30	15:00-15:30	8:00-8:30	12:30-13:00	17:00-17:30	19:00-19:30	00:00-00:30	03:00-03:30
9:30-10:00	15:30-16:00	8:30-9:00	13:00-13:30	17:30-18:00	19:30-20:00	00:30-01:00	03:30-04:00
10:00-10:30	16:00-16:30	9:00-9:30	13:30-14:00	18:00-18:30	20:00-20:30	01:00-01:30	04:00-04:30
10:30-11:00	16:30-17:00	9:30-10:00	14:00-14:30	18:30-19:00	20:30-21:00	01:30-02:00	04:30-05:00
11:00-11:30	17:00-17:30	10:00-10:30	14:30-15:00	19:00-19:30	21:00-21:30	02:00-02:30	05:00-05:30
11:30-12:00	17:30-18:00	10:30-11:00	15:00-15:30	19:30-20:00	21:30-22:00	02:30-03:00	05:30-06:00
12:00-12:30	18:00-18:30	11:00-11:30	15:30-16:00	20:00-20:30	22:00-22:30	03:00-03:30	06:00-06:30
12:30-13:00	18:30-19:00	11:30-12:00	16:00-16:30	20:30-21:00	22:30-23:00	03:30-04:00	06:30-07:00
13:00-13:30	19:00-19:30	12:00-12:30	16:30-17:00	21:00-21:30	23:00-23:30	04:00-04:30	07:00-07:30
13:30-14:00	19:30-20:00	12:30-13:00	17:00-17:30	21:30-22:00	23:30-24:00	04:30-05:00	07:30-08:00
14:00-14:30	20:00-20:30	13:00-13:30	17:30-18:00	22:00-22:30	00:00-00:30	05:00-05:30	08:00-08:30
14:30-15:00	20:30-21:00	13:30-14:00	18:00-18:30	22:30-23:00	00:30-01:00	05:30-06:00	08:30-09:00
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16:30-17:00	22:30-23:00	15:30-16:00	20:00-20:30	00:30-01:00	02:30-03:00	07:30-08:00	10:30-11:00
17:00-17:30	23:00-23:30	16:00-16:30	20:30-21:00	01:00-01:30	03:00-03:30	08:00-08:30	11:00-11:30

General Program

Abbreviation:

Session ML: Milano venue (Onsite)

Session PD: Purdue venue (Onsite)

Session AM: Digital Twin Additive Manufacturing

Session C: Digital Twin City

Session D: Digital Twin Design

Session DIA: Digital Twin Diverse Industrial Applications

Session EI: Digital Twin Energy Intelligence

Session ES: Digital Twin Electric and Energy Systems

Session HM: Digital Twin Health and Medicine

Session BJ: Beijing venue (Onsite)

Session IF: Digital twin Interdisciplinary Frontier

Session L: Digital twin logistics

Session N: Digital Twin Networks

Session OE: Digital Twin Ocean Engineering & Equipment

Session R: Digital Twin Reliability

Session SC: Digital Twin Smart Construction

Session SE: Digital twin Smart Engineering

Session SM: Digital Twin Smart Manufacturing

Milan Time (CET)	Beijing Time	Oct. 14th							
9:00-18:00	9:00-18:00	**Registration**							
Milan Time (CET)	**Beijing Time**	**Oct. 15th**							
9:00-9:30	15:00-15:30	**Opening Ceremony**							
9:30-10:00	15:30-16:00	**Keynote 1: Prof. Andrew YC Nee** *(Singapore)*							
10:00-10:30	16:00-16:30								
10:30-11:00	16:30-17:00	Coffee Break / Group Photo							
11:00-11:30	17:00-17:30	**Keynote 2: Prof. Nabil Anwer** *(France)*							
11:30-12:00	17:30-18:00								
12:00-12:30	18:00-18:30	Lunch Break							
12:30-13:00	18:30-19:00								
13:00-13:30	19:00-19:30	**Keynote 3: Prof. Fu Zhao** *(U.S.)*							
13:30-14:00	19:30-20:00								
14:00-14:30	20:00-20:30	**ML1**	**C 1 - C 7**	**EI 1 - EI 8**	**IF2-1 - IF2-8**	**OE1-1 - OE1-8**	**SC 1 - SC 7**	**SE 1 - SE 8**	**PD Day 1**
14:30-15:00	20:30-21:00	**ML2**							
15:00-15:30	21:00-21:30	**ML3**							
15:30-16:00	21:30-22:00	**ML4**							
16:00-16:30	22:00-22:30	Coffee Break							
16:30-17:00	22:30-23:00	**ML5**							
17:00-17:30	23:00-23:30	**ML6**							
17:30-18:00	23:30-24:00	**ML7**							
18:00-18:30	00:00-00:30	**ML8**							
20:00-20:30	02:00-02:30	**Welcome Dinner**							
20:30-21:00	02:30-03:00								

Milano Time (CET)	Beijing Time	Oct. 16th									
3:00-9:00	9:00-15:00										BJ(1-8)
9:00-9:30	15:00-15:30	**Keynote 4: Dr. Ang Liu** *(Australia)*									
9:30-10:00	15:30-16:00										
10:00-10:30	16:00-16:30	ML 9	ML 20	D 1 - D 5	ES 1 - ES 5	N 1 - N 6	IF1- 1 - IF1- 5	OE2-1 - OE2-5	SM1-1 - SM1-5	SM2-1 - SM2-5	SM3-1 - SM3-5	BJ 9 - BJ 13
10:30-11:00	16:30-17:00	ML 10	ML 21								
11:00-11:30	17:00-17:30	Coffee Break									
11:30-12:00	17:30-18:00	ML 11	ML 22								
12:00-12:30	18:00-18:30	ML 12	ML 23								
12:30-13:00	18:30-19:00	ML 13	ML 24								
13:00-13:30	19:00-19:30	Lunch Break									
13:30-14:00	19:30-20:00										
14:00-14:30	20:00-20:30	**Keynote 5: Mr. Mariani Livio** *(Italy)*									
14:30-15:00	20:30-21:00										
15:00-15:30	21:00-21:30	ML 14	ML 25	AM 1 - AM 6	DIA 1 - DIA 6	L 1 - L 6	IF1-6 - IF1-10	OE2-6 - OE2-10	R 1 - R 7	SM2-6 - SM2-11	SM3-6 - SM3-11	PD Day2
15:30-16:00	21:30-22:00	ML 15	ML 26									
16:00-16:30	22:00-22:30	ML 16	ML 27									
16:30-17:00	22:30-23:00	Coffee Break										
17:00-17:30	23:00-23:30	ML 17	HM									
17:30-18:00	23:30-24:00	ML 18										
18:00-18:30	24:00-24:30	ML 19										
Milano Time (CET)	Beijing Time	Oct. 17th									
9:00-9:30	15:00-15:30	**Keynote 6: Prof. Jan C. Aurich** *(Germany)*									
9:30-10:00	15:30-16:00										
10:00-10:30	16:00-16:30	**Keynote 7: Prof. Stefan Pickl** *(Germany)*									
10:30-11:00	16:30-17:00										
11:00-11:30	17:00-17:30	Coffee Break									
11:30-12:00	17:30-18:00	**Keynote 8: Prof. Daniel Krob** *(France)*									
12:00-12:30	18:00-18:30										
12:30-13:00	18:30-19:00	**Closing Ceremony**									
13:00-13:30	19:00-19:30										
13:30-14:00	19:30-20:00	Lunch Break									
14:00-14:30	20:00-20:30										
14:30-15:00	20:30-21:00	**Visiting of Company Center which located on campus**									
15:00-15:30	21:00-21:30										
15:30-16:00	21:30-22:00										
16:00-16:30	22:00-22:30	**Discussion on DigiTwin 2025**									
16:30-17:00	22:30-23:00										
19:30-20:00	01:30-02:00	**Farewell Dinner**									
20:00-20:30	02:00-02:30										
Milano Time (CET)	Beijing Time	**Oct. 18th**									
9:00-12:00	15:00-18:00	**Closed Meeting** *(For members of the organizing committee only)*									

OPENING CEREMONY

Tuesday, 15th October, 2024

（Milan Time） 9:00 - 9:30 （Beijing Time） 15:00 - 15:30

Tencent ID: 502-1550-7842

Weblink: https://meeting.tencent.com/dm/re95HNeoVy0c

Milan Time	Beijing Time	Agenda
9:00	15:00	**Welcome Address from DigiTwin2024 General Chair** Prof. Andrea Matta
9:05	15:05	**Digital Twin International Advisory Committee (DTIAC) Address** Prof. Alain Bernard
9:10	15:10	**Congratulatory Address** Eng Guan Ang (Managing Director of Taylor & Francis Group China)
9:15	15:15	**Welcome Address from DigiTwin2024 General Chair** Prof. Fei Tao

AWARDS AND CLOSING CEREMONY

Thursday, 17th October, 2024

（Milan Time） 12:30 - 13:30 （Beijing Time） 18:30 - 19:30

Tencent ID: 502-1550-7842

Weblink: https://meeting.tencent.com/dm/re95HNeoVy0c

Milan Time	Beijing Time	Agenda
12:30	18:30	**Introduction of award selection process for DigiTwin 2024** Prof. Xiaojun Liu
12:35	18:35	**Announcement of award recipients** Prof. Jan C. Aurich
13:05	19:05	**Introduction to the Digital Twin (Int. Journal)** Ms Qian JIAO, Taylor & Francis
13:10	19:10	**Introduction to the Digital Engineering (Int. Journal)** Ms Casey Guo, Elsiver
13:15	19:15	**Introduction of DigiTwin 2025 (Germany)** Prof. Stefan Pickl
13:20	19:20	**Announcement of DigiTwin 2026 (Sweden)** Dr. Wei Wang
13:25	19:25	**Acknowledgement** Prof. Andrea Matta

Keynote List

Tencent ID : 502-1550-7842
Weblink: https://meeting.tencent.com/dm/re95HNeoVy0c

Keynote 1	**Metaverse – crossing gaming to industry** **Prof. Andrew YC Nee** National University of Singapore (Singapore) SAEng Fellow、CIRP Fellow、SME Fellow
Keynote 2	**From Skin Model Shapes to Digital Twins: Challenges, opportunities and future directions for geometric tolerancing** **Prof. Nabil Anwer** Paris-Saclay University (France) CIRP Fellow, AET Fellow
Keynote 3	**Digital Twin Enabled Life Cycle Inventory Modelling – Building the Data Foundation for Sustainable Manufacturing** **Prof. Fu Zhao** Purdue University – West Lafayette (US) ASME Fellow
Keynote 4	**Digital Twin for Engineering Design** **Dr. Ang Liu** The University of New South Wales (Australia) ASME Fellow

Keynote List

Tencent ID : 502-1550-7842
Weblink: https://meeting.tencent.com/dm/re95HNeoVy0c

Keynote 5	**AI-powered Digital Twins** **Mr. Mariani Livio** Simulation Data & Digital Twin, Altair (Italy) Director, Global Biz. Dev
Keynote 6	**From Theory to the Shop Floor: Framework for Digital Twins in Manufacturing** **Prof. Jan C. Aurich** Institute for Manufacturing Technology and Production Systems (FBK), RPTU in Kaiserslautern (Germany) acatech Fellow, CIRP Fellow
Keynote 7	**Data-driven decision support in complex situations - IRIS Integrated Reachback Information System as hybrid optimization framework: Digital Twins for the Anomaly Detection of Complex Supply Chains** **Prof. Stefan Pickl** Bundeswehr University Munich (Germany) acatech Fellow
Keynote 8	**Systemic Digital Twins for Mastering Complex Industrial Operations - From System Modeling to System Simulation** **Prof. Daniel Krob** CESAMES, Systemic Intelligence (France) President, INCOSE Fellow

KEYNOTE 1

Tuesday, October 15th 2024

(Milan Time) 9:30 -10:30
(Beijing Time) 15:30-16:30

Tencent ID: 502-1550-7842



Prof. Andrew YC Nee

National University of Singapore (Singapore)
SAEng Fellow、CIRP Fellow、SME Fellow

Biography

Prof. Andrew Y. C. Nee received his Ph.D. degree from Victoria University of Manchester's Institute of Science and Technology in 1973. He joined the University of Singapore in 1974, where he was promoted to a full professor and appointed as Vice-Dean (Academic Affairs) in 1989. From 1993 to 1996, he served as the head of the Department of Mechanical Engineering and the Dean of the Faculty of Engineering from 1995 to 1998. From 2001 to 2002, he was appointed the Deputy Executive Director, Science and Engineering Research Council (SERC) of the National Science and Technology Board. He is a founding fellow of the Singapore Academy of Engineering, a fellow of the International Academy for Production Engineering (CIRP), and a fellow of the Society of Manufacturing Engineers (SME). He was elected President of CIRP in 2012, becoming the first ethnic Chinese to hold this position since 1953.

Title: Metaverse – crossing gaming to industry

Abstract

Metaverse is a digital copy of the real world, and it presents an entry point for fully connected, immersive and engaging 3D experience. It is a digital space where users can enter and interact with other users virtually. Metaverse is touted as the next generation of the Internet, although some argued it is a hype.

The origins and early development of Metaverse can be traced back to the virtual game platform such as the “Second Life” in the 1990s when Internet, VR and AR technologies began to flourish, laying the foundation for the construction of virtual worlds.

Metaverse can bring significant changes to manufacturing as it can account for how humans interact with factory equipment. Digital twins, already well established in the sector, are digital replicas of a system, but humans are not a dynamic part. On the other hand, the Metaverse allows humans to interact dynamically in environments made up of digital images.

This talk addresses the future development and challenges of DT in the Metaverse environment, where humans interact with DT facilities and Avatars which can be trained and impart knowledge to novice human operators.

KEYNOTE 2

Tuesday, October 15th 2024

(Milan Time) 11:00 -12:00
(Beijing Time) 17:00-18:00

Tencent ID: 502-1550-7842



Prof. Nabil Anwer

Paris-Saclay University (France)

CIRP Fellow, AET Fellow

Biography

Prof. Nabil Anwer is a Professor at Paris-Saclay University, France, and the deputy director of the Automated Production Research Laboratory (LURPA). He is fellow of the International Academy of Production Engineering (CIRP) and serves as the vice chairman of the scientific and technical committee Design (STC Dn). He is also fellow and council member of the International Academy of Engineering and Technology (AET), committee member of ISO TC 213 (Geometrical product Specifications and Verification) and ISO/IEC JTC1 SC 41 WG 16 (Digital Twin).

Prof. Nabil Anwer leaded and participated in several research projects funded by major French companies, French Inter-ministerial Fund, the French National Research Agency, and Horizon 2020 and Horizon Europe Research programs. He serves as associate editor or editorial/advisory board member for many famous Journals. He has published over 250 journal and conference papers.

Title: From Skin Model Shapes to Digital Twins: Challenges, opportunities and future directions for geometric tolerancing

Abstract

Geometrical Product Specifications and Verification (GPS) encompass different product development activities while considering variability and uncertainty inherent in manufacturing processes and systems. The advent of Skin Model Shapes represents a ground-breaking shift to supersede nominal ideal geometry for engineering applications and a new paradigm to encapsulate and manage product’ s geometrical variations throughout the design and manufacturing stages, and to leverage digital twins in geometrical variations management. Based on sound conceptualizations and discrete geometry representations, Skin Model Shapes have become a keystone for representing non-ideal surfaces, modelling geometric defects and capturing the geometric variability across product’ s lifecycle.

This presentation will explore the research challenges, opportunities and future directions enabled by Skin Model Shapes towards digital twins in mechanical engineering. First, we will lay the foundations of Skin Model Shapes and digital twins in the context of ISO GPS standards. Then, their applications in geometric tolerancing and shape processing will be discussed. Finally, opportunities and future directions for additive manufacturing, product digital twin, and machine learning will be explored.

KEYNOTE 3

Tuesday, October 15th 2024

(Milan Time) 13:00 -14:00
(Beijing Time) 19:00-20:00

Tencent ID: 502-1550-7842



Prof. Fu Zhao

Purdue University – West Lafayette (US)

ASME Fellow

Biography

Dr. Fu Zhao is a Professor with joint appointment in the School of Mechanical Engineering and the School of Environmental and Ecological Engineering at Purdue University. Dr. Zhao's research is largely in the area of environmentally sustainable design and manufacturing. He has extensive experience conducting life cycle assessment (LCA) for a variety of products and applications, including biofuel, solar thermal systems, traditional and additive manufacturing processes. His research has been supported by NSF, DOE, DOD, EPA, NIST, as well as industry. He has published more than 130 journal papers and over 50 conference proceedings. Dr. Zhao received his BS (1993) and MS (1996) degree, both in Thermal Engineering, from Tsinghua University. He received his second MS degree in Electrical Engineering-Systems (2001) and his PhD in Mechanical Engineering (2005) from the University of Michigan.

Title: Digital Twin Enabled Life Cycle Inventory Modelling – Building the Data Foundation for Sustainable Manufacturing

Abstract

Life cycle assessment (LCA) has been widely recognised as the most objective tool to evaluate the environmental performance of a product or process. LCA recently has attracted increasing interest, in part because it is the underlying method to support carbon footprint reporting. LCA also finds applications in supporting design and development of environmentally friendly products and technologies, including features/processes that realize circular economy. However, data quality and availability at unit process level have been cited as the biggest challenges faced by LCA community. Current life cycle inventory (LCI) databases have serious shortcomings and limitations: they are usually static and outdated, carry large uncertainties, are rather generic, and lack datasets on use phase and end of life management. Digital twin technologies create virtual replicates of physical assets by using high fidelity models and real time data collected from installed sensors. This opens up critical opportunities to advance LCI modeling. This talk will discuss the potential of using digital twins to address the major shortcomings and limitations of existing LCI modeling approaches as related to carbon footprint reporting at product level and green product/process development. Moreover, to apply digital twin based LCI modeling at supply chain or corporation level and to benefit the LCA community, algorithms and approaches that could enable proprietary information protection, data sharing, data validation, rewarding mechanisms are needed.

KEYNOTE 4

Wednesday, October 16th 2024
(Milan Time) 9:00 -10:00
(Beijing Time) 15:00-16:00

Tencent ID: 502-1550-7842



Dr. Ang Liu

The University of New South Wales (Australia)
ASME Fellow

Biography

Dr. Ang Liu is an Associate Professor of Engineering Design at the School of Mechanical and Manufacturing Engineering, University of New South Wales. Dr. Liu is a Fellow of ASME (American Society of Mechanical Engineers), Associate Member of International Academy for Production Engineering (CIRP), Invitational Fellow of JSPS (Japan Society for the Promotion of Science), Fellow of the PLuS Alliance, and Senior Fellow of the Higher Education Academy (SFHEA). He is Secretary of CIRP Scientific Technical Committee on Design in 2022-2025. He received multiple prestigious awards such as UNSW Vice-Chancellor’ s Award for Outstanding Contributions to Student Learning, one of the 250 Top Researchers by the Australian's Research Magazine 2021-2023, Outstanding Contributions to Student Learning of the 2022 Australian Awards for University Teaching (AAUT).

Title: Digital Twin for Engineering Design

Abstract

In the digital age, data has become the new "oil," essential for driving innovation and decision-making. Among the transformative technologies, Digital Twin (DT) stands out as a critical bridge between the physical and digital worlds, enabling seamless connection and communication. The integration of AI has significantly enhanced the capabilities of digital twins. Traditionally, engineering design involved extracting information from data, building knowledge, solving design challenges, and gaining insights through experience. However, with the advent of Industry 4.0, the design process is increasingly digitalized, and AI is at the forefront of this transformation. AI-powered digital twins can simulate, predict, and optimize every aspect of a product’ s lifecycle. Through advanced algorithms, AI analyzes vast amounts of data to provide real-time insights, driving smarter and more efficient design decisions. This capability allows for rapid adjustments and continuous improvement throughout the design and manufacturing processes, ensuring that products are optimized from concept to completion. In this presentation, we will explore how AI-driven digital twins are revolutionizing engineering design. We’ ll contextualize the emergence of digital twins within the broader shift toward data-driven design, highlighting AI's central role in this evolution. We will also examine the application of AI-enhanced digital twins across various stages of product design and outline a systematic approach to creating functional digital twin systems. Finally, we’ ll discuss the impact of AI-driven digital twins in innovative fields, such as the treatment of heart diseases.

KEYNOTE 5

Wednesday, October 16th 2024
(Milan Time) 14:00 -15:00
(Beijing Time) 20:00-21:00

Tencent ID: 502-1550-7842



Mr. Mariani Livio

Simulation Data & Digital Twin, Altair (Italy)
Director, Global Biz. Dev

Biography

Livio Mariano is serving as Director of Simulation Data and Digital Twin at Altair Engineering. With a passion for advancing cutting-edge technologies, he spearheads initiatives in artificial intelligence, digital twin development and systems integration. Livio plays a pivotal role in guiding companies towards enhanced efficiency and cost reduction throughout both the design and operational phases. Educationally, Mariano boasts a strong foundation, having earned his bachelor's degree in mechanical engineering. He further solidified his expertise by obtaining a master's degree in mechanical engineering with a specialized focus on mechatronics and robotics from the prestigious Polytechnic University of Milan.

Title: AI-powered Digital Twins

Abstract

Data-driven approaches are increasingly being used in engineering for system modeling. They significantly enhance the ability to generate efficient models that handle the complexity, nonlinearity, and high dimensionality of modern systems more effectively than traditional methods. Indeed, by learning underlying nonlinear relationships from experimental or simulation data -usually generated from computationally intensive high-fidelity models-, these approaches enable fast modeling and simulations without requiring a full mathematical description of the original system.

This leads to the ability to develop better products faster. AI enables engineers to explore many more ideas in even shorter timeframes. Today, advances in technology and computation have made this field easily accessible to everyone. Altair's AI solutions are successfully used worldwide, especially by those with no background in data science or programming.

In this talk, we will illustrate why AI is so important in the field of Digital Twins and the advantages of its adoption by presenting industrial applications.

KEYNOTE 6

Thursday, October 17th 2024

(Milan Time) 9:00 -10:00
(Beijing Time) 15:00-16:00

Tencent ID: 502-1550-7842



Prof. Jan C. Aurich

Institute for Manufacturing Technology and Production Systems (FBK), RPTU in Kaiserslautern (Germany)
acatech Fellow, CIRP Fellow

Biography

Prof. Jan C. Aurich received his Ph.D. degree from Leibniz University Hannover in 1995. From 1990 to 1995, he was a research assistant at the Institute for Production Engineering and Machine Tools, Leibniz University of Hanover, and led the "CAD/CAPP" team from 1993. From 1995 to 2002, he played a management role in both production and development departments at Daimler AG. In 2002, he became the chair professor of the Institute for Manufacturing Technology and Production Systems at TU Kaiserslautern. In 2013-2014, he was a Fulbright Visiting Professor at UC Davis, USA. Prof. Aurich is a member of the German National Academy of Science and Engineering (acatech) and the German Academic Association for Production Technology (WGP), and a fellow of the International Academy for Production Engineering (CIRP). His research interests include micro-manufacturing, product-service systems, sustainable manufacturing, and digital production.

Title: From Theory to the Shop Floor: Framework for Digital Twins in Manufacturing

Abstract

The concept of digital twins (DTs) revolutionizes modern manufacturing by enhancing the physical system with a digital system. However, a lack of consensus and uniform agreement on the definition of DT prevents the utilization of its full potential.

In a first step, various definitions of DTs, the different areas of application in manufacturing systems (factory, process, machine level), and different purposes (diagnosis, monitoring and control, prediction) are outlined. The benefits and challenges of DTs and the implementation in manufacturing systems are identified.

Afterwards, a review of current research regarding implemented applications of DTs in manufacturing scenarios is presented, resulting in an overview of recent advancements. Based on that, implications for future research directions are highlighted.

Finally, the paper proposes a novel framework designed for DTs in manufacturing. This framework serves as a foundation for further research and practical implementation within the industry.

KEYNOTE 7

Thursday, October 17th 2024
(Milan Time) 10:00 -11:00
(Beijing Time) 16:00-17:00

Tencent ID: 502-1550-7842



Prof. Stefan Pickl

Bundeswehr University Munich (Germany)
acatech Fellow

Biography

Prof. Dr. Stefan Wolfgang Pickl received his Ph.D. degree from TU Darmstadt in 1998 and his Habilitation in 2004/2005. From 2000 to 2005, he was a research assistant and project manager at the Center for Applied Informatics Cologne, focusing on modeling, simulation, and optimization of resource conflicts. Since July 2005, he served as the Chair of Operations Research at the Bundeswehr University Munich. Currently, Prof. Pickl is Deputy Chairman of the German Committee for Disaster Risk Reduction (DKKV) and Chairman of the Advisory Board of the German Society for Operations Research (GOR). In 2023, he was elected as a member of the German National Academy of Science and Engineering (acatech). His research interests are IT-based decision-making and process optimization.

Title: Data-driven decision support in complex situations - IRIS Integrated Reachback Information System as hybrid optimization framework: Digital Twins for the Anomaly Detection of Complex Supply Chains

Abstract

The supply chains considered currently need special attention to be optimized on complex disruptions that affect the general security of supply. As part of the research project »OPERA - Future Operations« an interdisciplinary consortium develops a trend-setting interactive visualization tool to support decision makers politics, to adapt and to explore different strategies especially with the aid of digital twins. This talk gives an overview on that project. Furthermore it presents the special sector-based approach IDEA4C as part of the IRIS project:

I - Identification of critical regions, sectors and coupling principles **Cost-Benefit Analysis for critical sectors**
D - Data-driven constraint optimization **Coupled Sector-based Models**
E - Exploratory Strategies/ Recognition of critical pathways and sectors **Characterization of Pathways**
A - Adaptation and Quantifying Analysis **Coordination of Strategies**

This 4C-approach describes a new integrated modelling suite for developing and assessing relief distribution strategies. With the aid of a digital twin "IRIS" approach, anomaly detection should be supported. This hybrid optimization framework as example for IRIS has been conceptualized and is currently being developed with and for experts in the field of disaster and emergency management, in order to tackle the real issues arising during such this crisis.

KEYNOTE 8

Thursday, October 17th 2024
(Milan Time) 11:30 -12:30
(Beijing Time) 17:30-18:30

Tencent ID: 502-1550-7842



Prof. Daniel Krob

CESAMES, Systemic Intelligence (France)
President, INCOSE Fellow

Biography

Daniel Krob is currently president, both of CESAMES, the leading French company in systems architecting & engineering, and of Systemic Intelligence, a startup focused on an innovative systemic digital twin technology, WorldLab.

Daniel Krob was also institute professor in computer science at Ecole Polytechnique, France (2001-2019) and founder & head of the Ecole Polytechnique – Thales industrial chair "Engineering of complex systems" (2003-2015). Recently he was nominated distinguished visiting professor at Tsinghua University, China.

Daniel Krob wrote more than 100 scientific papers on various subjects (algebraic and enumerative combinatorics, control theory, discrete mathematics, mobile communications, quantum groups, signal processing, system theory, theoretical computer science.) He is the author of several books and of five patents.

Nowadays Daniel Krob specialized in systems architecting, engineering, modelling and simulation. He worked for major international companies (aeronautics, automotive, bank, energy, high tech, railway, services and space).

Title: Systemic Digital Twins for Mastering Complex Industrial Operations - From System Modeling to System Simulation

Abstract

We introduce the fundamentals of "systemic digital twins", a new concept for simulation & optimization at system level of complex industrial processes. Our approach is based on the WorldLab technology that allows to produce automatically the systemic digital twin of an industrial system from a MBSE model through a specification designed in the S formal modeling language. This formal language can be used to specify the structure and the behavior of any industrial system and to capture probabilistic behaviors and hazards. An industrial case study – on the transformation of a French harbour – will be discussed in details.

Sessions List

No.	Abbrs.	Topic	Chairs	Meeting ID
1	Session ML	DigiTwin 2024 (Milan, Italy)	**Dr. Ying CHENG** Beihang University (China) **Dr. Macchi MARCO** Politecnico di Milano (Italy)	Tencent ID : 502-1550-7842 249-162-652
2	Session BJ	DigiTwin 2024 Sub-venue 1 (Beijing, China)	**Dr. Qinglin QI** Beihang University (China)	Tencent ID : 525-153-053
3	Session PD	DigiTwin 2024 Sub-venue 2 (Purdue University, USA)	**Prof. Ragu ATHINARAYANAN** **Prof. Martin JUN** **Dr. Thorsten WUEST** **Dr. Xingyu LI** Purdue University (United States)	Tencent ID : 798-434-188
4	Session SM1	Digital Twin Smart Manufacturing I	**Prof. Haisong HUANG** Guizhou University (China) **Dr. Kai YANG** Guizhou University (China)	Tencent ID : 490-178-240
5	Session SM2	Digital Twin Smart Manufacturing II	**Prof. Guohong DAI** Jiangsu University of Technology (China) **Prof. Patrick RUEDIGER-FLORE** Department of Mechanical and Process Engineering of RPTU (Germany) **Dr. Yuan CHAO** Jiangsu University of Technology (China) **Dr. Chao TAN** Jiangsu University of Technology (China)	Tencent ID : 479-167-293
6	Session SM3	Digital Twin Smart Manufacturing III	**Dr. Shimin LIU** Hong Kong Polytechnic University (China) **Dr. Zheng PAI** Hong Kong Polytechnic University (China)	Tencent ID : 276-671-904
7	Session IF 1	Digital twin Interdisciplinary Frontier I	**Prof. Stefan PICKL** Guizhou University (China) **Prof. Fei TAO** Beihang University (China) **Dr. Yupeng WEI** Beihang University (China) **Dr. Marvin MAY** University of Kaiserslautern-Landau (Germany)	Tencent ID : 258-451-103
8	Session IF2	Digital twin Interdisciplinary Frontier II	**Prof. Fei TAO** Beihang University (China) **Prof. Nabil ANWER** Paris-Saclay University (France) **Dr. Qinglin QI** Beihang University (China)	Tencent ID : 886-136-546

(To be continued)

(Continued from the previous page)

No.	Abbrs.	Topic	Chairs	Meeting ID
9	**Session DIA**	Digital Twin Diverse Industrial Applications	**Dr.-Ing. Li YI** Beihang University (China) **Dr.-Ing. Matthias KLAR** University of Kaiserslautern-Landau (Germany)	Tencent ID : **735-800-340**
10	**Session OE1**	Digital Twin Ocean Engineering & Equipment I	**Prof. Honggen ZHOU** Jiangsu University of Science and Technology (China) **Dr. Jinfeng LIU** Jiangsu University of Science and Technology (China) **Dr. Vsevolod V. KORYANOV** Moscow State Bauman Technical University (Russia) **Prof. Xuwen JING** Jiangsu University of Science and Technology (China)	Tencent ID : **348-408-610**
11	**Session OE2**	Digital Twin Ocean Engineering & Equipment II	**Prof. Yanjun LIU** Shandong University (China) **Prof. Elena De MOMI** Politecnico di Milano (Italy) **Prof. Hongda SHI** Ocean University of China (China)	Tencent ID : **770-109-243**
12	**Session N**	Digital Twin Network	**Dr. Tao SUN** China Mobile Research Institute (China) **Dr. Diego LOPEZ** Telefonica I+D, Spain (Spain) **Dr. Stephen TERRILL** Ericsson, Swed (Australia)	Tencent ID : **657-553-963**
13	**Session ES**	Digital Twin Electric and Energy Systems	**Prof. Li WANG** Nanjing University of Aeronautics and Astronautics (China) **Dr. Qunfang WU** Nanjing University of Aeronautics and Astronautics (China) **Dr. Kangkang ZHANG** Imperial College London (UK)	Tencent ID : **321-839-619**
14	**Session D**	Digital Twin Design	**Dr. Ang LIU** University of New South Wales (Austrlia)	Tencent ID : **967-819-238**
15	**Session AM**	Digital Twin Additive Manufacturing	**Prof. Kunpeng ZHU** Wuhan university of science and technology (China) **Prof. Xin LIN** Wuhan university of science and technology (China)	Tencent ID : **164-366-392**
16	**Session EI**	Digital Twin Energy Intelligence	**Prof. Xuhui ZHANG** Xi 'an University of Science and Technology (China) **Prof. Xuewen WANG** Taiyuan University of Technology (China) **Prof. Yinan GUO** China University of Mining & Technology (China)	Tencent ID : **425-418-722**

(To be continued)

(Continued from the previous page)

No.	Abbrs.	Topic	Chairs	Meeting ID
17	**Session SC**	Digital Twin Smart Construction	**Prof. Zhansheng LIU** Beijing University of Technology (China) **Dr. Zhe SUN** Beijing University of Technology (China) **Dr. Fengjuan CHEN** Beijing University of Technology (China)	Tencent ID : **258-954-982**
18	**Session R**	Digital Twin Reliability	**Prof. Yi REN** Beihang University (China) **Dr. Cheng QIAN** Beihang University (China) **Dr. He LI** University of Lisbon (Portugal)	Tencent ID : **443-161-146**
19	**Session SE**	Digital twin Smart Engineering	**Prof. Ying LIU** Cardiff University (UK) **Prof. Yu ZHENG** Shanghai Jiaotong University (China) **Prof. Xiaohui CHEN** Chongqing University (China) **Dr. Xiao GUO** Cardiff University (UK) **Prof. Sibao WANG** Chongqing University (China)	Tencent ID : **365-877-085**
20	**Session C**	Digital Twin City	**Prof. Cecilia BOLOGNESI** Politecnico di Milano (Italy) **Dr. Qian-Cheng WANG** University of Cambridge (UK) **Dr. Xuan LIU** Eindhoven University of Technology (Netherlands)	Tencent ID : **202-107-096**
21	**Session HM**	Digital Twin Health and Medicine	**Prof. Dedong MA** Qilu Hospital of Shandong University (China) **Prof. Gang HOU** China-Japan Friendship Hospital (China)	Tencent ID : **249-162-652**
22	**Session L**	Digital Twin Logistics	**Prof. Ning ZHAO** University of Science and Technology Beijing (China) **Prof. Ting QU** Jinan University (China) **Prof. Wenfeng LI** Wuhan University Of Technology (China) **Dr. Haobin LI** National University of Singapore (Singapore) **Dr. Jianbin XIN** Zhengzhou University (China)	Tencent ID : **734-244-443**

DigiTwin 2024 Main-venue (ML)

Chair



Ying CHENG

Associate Professor

Beihang University (China)

Co-Chair



Macchi MARCO

Associate Professor

Politecnico di Milano (Italy)

Session on

DigiTwin 2024 (Milano)

Tuesday, October 15th 2024

Tencent ID: 502-1550-7842
Weblink: https://meeting.tencent.com/dm/re95HNeoVy0c

Milan Time	Beijing Time	Agenda
14:00	20:00	**ML-1** Digital Twins as Enablers for Collaborative Ship Powertrain Design Riku Ala-Laurinaho
14:30	20:30	**ML-2** Digitalization of laser welding applications in EV manufacturing Wei Wang
15:00	21:00	**ML-3** Unlocking the Potential of Digital Twins in Manufacturing Systems through Process Mining Giovanni Lugaresi
15:30	21:30	**ML-4** Intelligent failure analysis for industry 4.0 based on multimodal data: Progress and challenges Zhiqiang Wang
16:00	22:00	Coffee break
16:30	22:30	**ML-5** Digital Twin for Smart Cities Davood Shojaei
17:00	23:00	**ML-6** Digital Twins for Advanced Manufacturing: The Standardized Approach Guodong Shao
17:30	23:30	**ML-7** The Practice and Thinking of Digital Twin Technology in Heavy Equipment Industry Yongjun Qie
18:00	24:30	**ML-8** Digital Twin Enhancing Human-Machine Integration Tianliang Hu

Session on

DigiTwin 2024 (Milano)

Wednesday, October 16th 2024

Tencent ID: 502-1550-7842 for ML9- ML19
249-162-652 for ML20- ML27

Weblink: https://meeting.tencent.com/dm/re95HNeoVy0c
https://meeting.tencent.com/dm/wtCvSssZfNgG

Milan Time	Beijing Time	Agenda
10:00	16:00	**ML-9** Digital twin-assisted multi-agent human and robot collaborative disassembly system platform towards retired EV battery recycling Jinhua Xiao
		ML-20 Digital Twin in Railways: Current Landscape, Challenges, and Architectural Foundations Hibat Allah BABTY
10:30	16:30	**ML-10** Application of digital twins in monitoring of complex transient welding manufacturing process Kai Yang
		ML-21 Integrated Modeling of SSPC for Digital Twin Virtual Entity Applications: Coupling Electro, Thermal, and Stress Fields Yongsheng He
11:00	17:00	Coffee break
11:30	17:30	**ML-11** Target-Oriented and Benefit-Centred Development and Implementation of Digital Twins in Manufacturing Companies Christian Kober
		ML-22 Digital Twin-driven bottleneck prediction in manufacturing systems: enhancing performance through adaptive production control L Ragazzini, E Negri, L Fumagalli, M Macchi
12:00	18:00	**ML-12** Research on the Design of Interactive Display Equipment for Ancient Books Xiao Guo
		ML-23 Digital Twin Framework for Advanced Fault Detection and Localization of Lithium-Ion Batteries Yiqi JIA
12:30	18:30	**ML-13** A digital twin of every US building – how to and active uses Joshua New
		ML-24 Deep Learning Meets Active Inference for Digital Twin Applications in Energy-Efficient Control of Parallel Machines Yavar Taheri Yeganeh, Mohsen Jafari, Andrea Matta

Session on

DigiTwin 2024 (Milano)

Wednesday, October 16th 2024

Tencent ID: 502-1550-7842 for ML9- ML19
249-162-652 for ML20- ML27
Weblink: https://meeting.tencent.com/dm/re95HNeoVy0c
https://meeting.tencent.com/dm/wtCvSssZfNgG

Milan Time	Beijing Time	Agenda
15:00	21:00	**ML-14** Data and models -driven efficient assembly method for ship hull ribs Jinfeng Liu
		ML-25 Advances in metacosmic medicine Chunxue Bai
15:30	21:30	**ML-15** Enhancing Digital Twin Insights and Synchronization: The Role of Explainable Machine Learning Anna Presciuttini
		ML-26 To be announced Peppino Paffi
16:00	22:00	**ML-16** A digital twin model of urban utility tunnels and its application Jiansong Wu(Chen Fan)
		ML-27 Inhaled drug efficacy prediction based on digital twin technology Dedong Ma
16:30	22:30	Coffee break
17:00	23:00	**ML-17** Towards Comprehensive Digital Twin Solutions in Manufacturing: Integrating Maturity Models and Advanced Capabilities LF Villegas, M Macchi, A Polenghi
17:30	23:30	**ML-18** Digital twin-based modeling of natural gas leakage and dispersion in urban utility tunnels Jitao Cai
18:00	24:00	**ML-19** Consensus Strategies of Manufacturing Service Collaboration in Digital Twin Shop-floor Ying Cheng

DigiTwin 2024 Main-venue（ML-1）



Riku Ala-Laurinaho

Head of DigiTwin Lab,
Aalto University (Finland)

Title:

Digital Twins as Enablers for Collaborative Ship Powertrain Design

Abstract

Ships are complex mechanical systems consisting of components from several competing vendors. Ensuring the compatibility of these components is crucial to reaching the optimal performance of the ship, minimizing fuel consumption, and reducing the maintenance need. Currently, analysis of the compatibility of the components necessitates a considerable amount of manual work, as the components are not shared openly and finding component information is laborious. This results in a current design paradigm with suboptimal components and a lack of collaboration between vendors and system integrators. This presentation proposes a paradigm shift towards a more collaborative and automated design of ship powertrains using intellectual property (IP)-protected digital twins that are shared openly. The proposed approach relies on Digital Twin Web, SSP (System Structure and Parameterization) and FMU (Functional Mockup Interface) standards, and ontologies. This approach allows an iterative development of the ship powertrain, during which both the components and system design are adjusted based on simulation results. The ship powertrain can be optimized earlier in the production process, and fewer adjustments are needed in the later design and production phases. Ultimately, this leads to better performance of ships with less manual work.

DigiTwin 2024 Main-venue（ML-2)



Wei Wang

Senior Lecturer
University of Skövde, Sweden (Sweden)

Title:

Digitalization of laser welding applications in EV manufacturing

Abstract

The automobile industry is shifting from traditional internal combustion engine vehicles (ICEV) to electric vehicles (EV). Comparing with ICEV components that mainly involves machining processes, the manufacturing of EV components, such as electrical machines and battery packs, have high requirements on connecting processes. For example, hairpin winding and battery pack assembly. Both hairpin winding and battery pack assembly are characterized by a high number of junctions. Moreover, there is very small room for hairpin winding tool as the hairpins of stators and rotors are distributed tightly. Therefore, laser welding stands out in terms of its flexibility and high efficiency. Moreover, the product life cycle of EVs is shorter than ICEV, the traditional statistical-based manufacturing process development methodology cannot meet the requirements of rapid evolvement of EVs. Therefore, using digitization techniques to develop stable manufacturing processes draw significant attention of automotive industry. Within the context, this presentation will provide an overview of research on digitalization of laser welding application for EV components manufacturing at University of Skövde collaborated with Swedish automobile industry.

DigiTwin 2024 Main-venue（ML-3)



Giovanni Lugaresi

Assistant Professor,
KU Leuven (Belgium)

Title:

Unlocking the Potential of Digital Twins in Manufacturing Systems through Process Mining: Research Opportunities

Abstract

The productivity benefits from recent investments in increased automation came along with a greater complexity in manufacturing systems. This necessitates the introduction of digital support tools, especially digital twins, for tasks such as production planning and control. Process mining has proven to be a valuable tool for several phases of digital twinning, demonstrating its effectiveness in model generation, trace profiling, and performance evaluation. There are still significant challenges in both methodological and application areas, offering valuable opportunities for academia and industry. This presentation highlights several topics at the intersection of process mining and digital twins in manufacturing systems, with an overview of recent projects and a reflection on research opportunities.

DigiTwin 2024 Main-venue（ML-4)



Zhiqiang Wang

Associate Professor,
Léonard de Vinci Pôle Universitaire (France)

Title:

Intelligent failure analysis for industry 4.0 based on multimodal data: Progress and challenges

Abstract

Failure Analysis (FA) involves analyzing production data to identify root causes of failures and develop strategies to eliminate Failure Mechanisms (FM), crucial in industries like automotive, aerospace, marine, and semiconductors. In these sectors, failures may arise from manufacturing, design, environmental factors, or maintenance issues. With advances in AI, automating FA using multimodal data (numerical, textual, image) is increasingly feasible. AI techniques such as Natural Language Processing (NLP) and computer vision convert this data into numerical formats for modeling with machine learning. This study predicts failure causes using AI on multimodal data from industry settings. A classification method applied to aeronautical machining data achieves 98.9% accuracy, and an NLP approach evaluated on semiconductor data reaches 97.8% accuracy. These methods help experts identify failure causes more accurately and efficiently. Future work will focus on developing a decision-aid system using multimodal data within a digital twin framework.

DigiTwin 2024 Main-venue（ML-5)



Davood Shojaei

Senior Lecturer,
The University of Melbourne (Australia)

Title:

Digital Twin for Smart Cities

Abstract

Digital Twin technology is transforming smart cities by creating real-time virtual replicas of urban environments. These dynamic models integrate data from sensors and IoT devices to optimize infrastructure, transportation, energy use, and public safety. By providing a constantly updated view of the city, Digital Twins enable better decision-making, predictive maintenance, and resource efficiency. They also help simulate the impacts of new developments and environmental changes, offering a powerful tool for sustainable urban planning. In this presentation, we’ ll explore how Digital Twins are reshaping city management and unlocking new possibilities for smarter, more efficient cities.

DigiTwin 2024 Main-venue（ML-6)



Guodong Shao

Computer Scientist
the National Institute of Standards and Technology (NIST) (US)

Title:

Digital Twins for Smart Manufacturing: The Standardized Approach

Abstract

Manufacturing is undergoing a digital transformation. As the foundation of that digital transformation, digital twins enable manufacturers to represent, diagnose, predict, and optimize their operations. However, there are significant challenges for manufacturers, especially small and medium-sized enterprises, in implementing digital twin applications correctly and effectively. While individual companies are starting to deploy and evaluate digital twins, the lack of relevant standards for digital twins is a barrier to broader adoptions. Standards for digital twins, including vocabulary, reference architecture, interoperability, and trustworthiness, are needed. . This presentation will discuss the categorizations of digital twin applications in manufacturing; introduce the current relevant standards and consortium efforts, focusing on the ISO digital twin framework standard and exploring potential new topics for standardization.

DigiTwin 2024 Main-venue（ML-7)



Yongjun QIE

Deputy General Manager , Head of Digital Twin Institute
SANY Group (China)

Title:

The Practice and Thinking of Digital Twin Technology in Heavy Equipment Industry

Abstract

Firstly, based on the complex operation scenarios of heavy equipment products. This report will analyze the value and differentiation of simulation technology and digital twin technology to improve the competitiveness of heavy equipment. Secondly, this report will introduce the key technologies of digital twin based on system engineering process and model-based system engineering methodology. Finally, this report will introduce the application scenarios and best practices of digital twin technology in heavy equipment research and development, such as product performance optimization and PHM.

DigiTwin 2024 Main-venue（ML-8)



Tianliang Hu

Professor,
Shandong University (China)

Title:

Digital Twin Enhancing Human-Machine Integration

Abstract

In recent years, digital twins have received extensive attention and applications across various industries. This report, commencing from the issues in the development of human-machine integration, will discuss the advantages and implementation pathways of digital twins in the field of human-machine integration. First, it will introduce the evolution of human-machine integration and analyze the current problems and their root causes from a digital perspective. Then, it will explain the basic concept and evolution of digital twins, as well as their advantages in the field of human-machine integration. Subsequently, combined with a practical application example, it will elaborate on the implementation methods of digital twins in human-machine integration, including the implementation framework based on perception, decision-making, and execution utilizing digital twins. Finally, the challenges of digital twins in research and engineering applications will be explored.

DigiTwin 2024 Main-venue（ML-9)



Jinhua Xiao

Assistant Professor,
Politecnico di Milano (Italy)

Title:

Digital twin-assisted multi-agent human and robot collaborative disassembly system platform towards retired EV battery recycling

Abstract

Nowadays, with the development of green manufacturing and cycling re-manufacturing, the recycling of retired products and related resource has gradually been paid attention to accomplish the sustainable and green productions. The disassembly as an important step in the recycling process can provide the automation technology based on robots that can accomplish many complex re-manufacturing tasks. Due to the high complexity and diversity of disassembly object products, manual disassembly is difficult to accomplish the economically efficient disassembly. Therefore, the robot application has many advantages on dealing with complex disassembly operations, but resulting in enough not flexible disassembly. This study proposes a digital twin-assisted multi-agent human and robot collaborative disassembly operations for uncertain conditions. This method discusses the flexibility and intelligence of human as operators, and the repeatability and high-accuracy of robots to deal with complicated disassembly tasks. By combining digital twin data platform, it can be easily solving the problems of real-time disassembly process and the dynamic disassembly task allocation can be used to improve the effectiveness of disassembly primarily based on a case of electric vehicle (EV) battery.

DigiTwin 2024 Main-venue（ML-10)



Kai Yang

Associate Professor
Guizhou University (China)

Title:

Application of digital twins in monitoring of complex transient welding manufacturing process

Abstract

Welding is an important material forming and processing technology in modern manufacturing industry, which is widely used in aerospace, rail transit, ocean engineering, energy and other fields. At present, welding intelligence is one of the most challenging research hotspots in the manufacturing field. The report introduces the development status of advanced welding process monitoring technology and analyzes the problems existing in traditional monitoring methods. Then, the monitoring method of welding process driven by digital twin is put forward, and the framework, implementation scheme and technical difficulties of welding process digital twin model are discussed. Finally, the realization method of welding digital twin system and its application cases are introduced, and its future development direction is prospected.

DigiTwin 2024 Main-venue（ML-11)



Christian Kober

Research Associate

a) Institute of Production Engineering, Helmut Schmidt University Hamburg (Germany)

b) Institute for Manufacturing, University of Cambridge (UK)

c) Laboratory for Industry 4.0 Smart Manufacturing Systems, University of Auckland (New Zealand)

Title:

Target-Oriented and Benefit-Centred Development and Implementation of Digital Twins in Manufacturing Companies

Abstract

In industrial manufacturing, there's a growing trend towards increased individualisation alongside high

production volumes. Digitalisation, particularly through Industry 4.0 and 5.0, offers significant potential to

accelerate this trend. Digital Twins (DT) play a crucial role in enhancing transparency and linking isolated

company areas. However, as of 2024, DT projects still exhibit low maturity levels in industry despite extensive research. This presentation explores the reasons behind the low maturity of DTs in manufacturing, identifying technical, organisational, and methodological challenges. Key issues include costs, acceptance, and target-setting. To address these challenges, a novel, comprehensive framework has been developed and validated. This framework systematically improves the development and implementation of DTs, as demonstrated by an in-depth case study in an innovative sawmill. The framework's application supports manufacturing companies in achieving optimal cost-benefit ratios, promoting informed decision-making and enhancing DT adoption.

DigiTwin 2024 Main-venue（ML-12)



Xiao Guo

Associate Professor,
Guizhou University/Dalian Minzu University (China)

Title:

Research on the Design of Interactive Display Equipment for Ancient Books

Abstract

With the trend towards interactivity in exhibition methods, the demand for interactivity has further increased, resulting in accelerated damage to ancient books in exhibitions. This article proposes the integration of advanced intelligent control technology, interactive projection technology, and IoT application technology to design display equipment, ensuring the integrity of ancient books while achieving interaction with visitors.

DigiTwin 2024 Main-venue（ML-13)



Joshua New

Ph.D., C.E.M., PMP, CMVP, IREE, Distinguished R&D Staff Member
Oak Ridge National Laboratory (US)

Title:

A digital twin of every US building – how to and active uses

Abstract

Buildings in the United States account for 73% of electricity use on the nation’s grid (80% during peak demand), 40% of primary energy use, and 39% of concomitant greenhouse gas emissions. After 5 years of effort, our team successfully created a model of 141.5 million US buildings. This was done by mining imagery (satellite, aerial, street-view), LiDAR, multiple listing services, and databases for buildings to consolidate the unique footprint, height, age of construction, and other properties necessary to create a building energy model, and simulate each U.S. building with typical weather for that area to estimate baseline energy use and validate against utility data. Building improvements have been simulated (e.g. bit.ly/virtual_epb) to inform projects in multiple industries including Google’s Environmental Insights Explorer aimed at reducing the carbon footprint of 40,000 cities internationally. The digital twin data for 125.7 million US buildings and OpenStudio/EnergyPlus models for 122,146,671 have been made open-source (bit.ly/ModelAmerica1) and software developed to help inform best practices for urban-scale energy modeling (bit.ly/AutoBEM).

DigiTwin 2024 Main-venue（ML-14)



Jinfeng Liu

Associate Professor,
Jiangsu University of Science and Technology (China)

Title:

Data and models -driven efficient assembly method for ship hull ribs

Abstract

At present, in the assembly of ship hull ribs, manual experience is often used as the standard for repeated trial and assembly, which consumes a lot of time and labor, seriously affecting the efficiency and cost of ship hull rib assembly. Therefore, an efficient assembly method for rib plates based on measured data and twin model driven is proposed. We have developed an efficient method for collecting and modeling large-scale component point cloud data by utilizing point cloud feature recognition and efficient fitting techniques; A method for optimizing assembly clearance based on the coordinated pose of ship hull ribs was proposed, which includes optimizing the pulling path of components and quantitatively repairing assembly interference; Through case sharing and system testing, verify the methods of large-scale component reconstruction and ship rib assembly clearance optimization, and guide efficient on-site ship assembly.

DigiTwin 2024 Main-venue（ML-15)



Anna Presciuttini

Ph.D. Candidate,
Politecnico di Milano (Itay)

Title:

Enhancing Digital Twin Insights and Synchronization: The Role of Explainable Machine Learning

Abstract

In recent years, the manufacturing sector has undergone significant transformation driven by Industry 4.0 technologies like Big Data, Cloud Computing and Internet of Things (IoT). Among them Digital Twins (DTs) play a crucial role by enabling real-time synchronization with physical systems, improving monitoring and decision-making processes. DTs leverage sensor data and machine learning (ML) algorithms to predict future states and support key tasks such as health monitoring and fault detection. However, many ML models lack transparency, hindering trust in DTs systems. Explainable AI (XAI) addresses this issue by making ML models more interpretable, increasing confidence in their predictions. Additionally, XAI can improve resource allocation by highlighting the most critical variables for accurate predictions, reducing the time and cost resources required to maintain DTs in real-time. This presentation will demonstrate how incorporating XAI into DTs can improve their transparency while optimizing resource management, driving greater efficiency in the manufacturing sector.

Federica Costa and Anna Presciuttini

DigiTwin 2024 Main-venue（ML-16)



Jiansong Wu

Professor,
China University of Mining and Technology-Beijing (CUMTB), (China)

Title:

A digital twin model of urban utility tunnels and its application

Abstract

Multiple pipelines in utility tunnels may lead to various accidents and serious social impact. In the era of digitalization, how to better model the operation of a utility tunnel, dynamically predict the accident evolutions, and support corresponding decision-makings are essential issues. In this talk, we propose a digital twin model for utility tunnel applied to accident and routine, which combines CFD, IoT, and OPC UA information model for data interaction, accident prediction, and emergency control. The proposed predictive digital twin technology facilitates the rapid risk assessment of and emergency management of natural gas accidents in utility tunnels.

DigiTwin 2024 Main-venue（ML-17)



LF Villegas Torres

PhD student ,
Politecnico di Milano (Italy)

Title:

Towards Comprehensive Digital Twin Solutions in Manufacturing: Integrating Maturity Models and Advanced Capabilities

Abstract

This research presents a comprehensive framework that integrates maturity models with advanced capabilities to unlock the full potential of Digital Twin across the manufacturing domains. By exploring how Digital Twins evolve from basic digital replicas to intelligent, autonomous systems, we propose a structured approach to assess DT maturity across predictive, prescriptive, and autonomous stages. Furthermore, this study highlights the critical role of emerging technologies—such as artificial intelligence, machine learning, and IoT—in enhancing the functionality and adaptability of Digital Twins. Through this integrated framework, we provide insights into how manufacturers can strategically implement and evolve Digital Twin solutions, driving efficiency, sustainability, and innovation for smart manufacturing solutions.

LF Villegas, M Macchi, A Polenghi

DigiTwin 2024 Main-venue（ML-18)



Jitao Cai

PhD student，China University of Mining and Technology-Beijing (CUMTB), (China)

Visiting researcher, University of Manchester (UK)

Title:

Digital twin-based modeling of natural gas leakage and dispersion in urban utility tunnels

Abstract

As an innovative and effective techniques for managing complex properties, digital twins hold great potentials to be applied in accident response scenarios. In this talk, we proposed a data-calibrated gas concentration prediction (DC-GCP) model to modeling natural gas leakage and dispersion in urban utility tunnels. By leveraging GPU-based Lattice Boltzmann method, data assimilation, and real-time data, the proposed DC-GCP model can realize accurate spatiotemporal predictions of gas concentrations and source term estimation. The results of twin experiments and statistical performance measures (SPMs) demonstrated the effectiveness of the proposed approach, showing a relative error of less than 5% for both predicted gas concentration and source parameter estimations. This study could be beneficial for dynamic risk assessment and emergency response in gas leakage accidents, as well as facilitating the implementation of predictive digital twin in utility tunnels.

DigiTwin 2024 Main-venue（ML-19)



Ying Cheng

Associate Professor,
Beihang University (China)

Title:

Consensus Strategies of Manufacturing Service Collaboration in Digital Twin Shop-floor

Abstract

Manufacturing Service Collaboration (MSC) enables the integration and aggregation of manufacturing resources and services to effectively address complex, customized, and flexible manufacturing demands. However, when MSC is carried out in the digital twin shop-floor, there are difficulties in the access of production services with data interaction latency, complex element collaboration relationships, and unsynchronised interactions. Therefore, it is essential to realise an accurate consensus mapping of different MSC processes. In this talk, our latest research progress in this area will be presented. Firstly, Collaboration mechanisms are investigated that covers five stages of digital twin service collaboration. The three-level consensus control strategies are proposed that account for the time delay between services' cyber-physical interaction and collaboration interaction among different services. Finally, the efficiency of the consensus strategies and consensus collaboration mechanism is demonstrated by the case study on the Surface Mounted Technology (SMT) process, and the existence of time delay with threshold is analyzed and demonstrated, which can be calculated from the control parameters and network topology.

DigiTwin 2024 Main-venue（ML-20)



Hibat Allah BABTY

PhD student ,
UTC (Université de Technologie de Compiègne) (France)

Title:

Digital Twin in Railways: Current Landscape, Challenges, and Architectural Foundations

Abstract

The railway sector, a backbone of sustainable transport, is undergoing significant industrial changes due to the ecological transition and digital revolution. The ultimate goals are to reduce greenhouse gas emissions by 55% by 2030 and achieve carbon neutrality by 2050. The digital twin (DT) became a key term in 2023, especially with the French Standardization Association (AFNOR) publishing the international standard ISO/IEC 30173:2023, "Digital Twin— Concepts and Terminology." This provides a starting point for many industries. The presentation will address the gaps in the railway sector regarding DT implementation and the challenges posed by its complexity due to the interactions between different components. It will also compare the status of DT in the railway sector with other industries. Additionally, it will discuss the development of a general digital twin architecture framework for railway infrastructures, anticipating the future ISO/IEC 30188 "Digital Twin— Reference Architecture".

Hibat Allah BABTY, Matthieu BRICOGNE, Etienne PANSART, Benoit EYNARD

DigiTwin 2024 Main-venue（ML-21)



Yongsheng He

PhD student,

Nanjing University of Aeronautics and Astronautics (China)

Title:

Integrated Modeling of SSPC for Digital Twin Virtual Entity Applications: Coupling Electro, Thermal, and Stress Fields

Abstract

Solid-State Power Controllers (SSPCs) are pivotal components in aerospace power distribution systems，which are central to developing more efficient, reliable, and environmentally friendly aircraft power systems. The intricate interactions among their multi-physical fields pose significant challenges to accurately characterizing their operational properties. Overcoming these challenges is essential for advancing green aviation and smart aerospace systems. Digital twin technology plays a crucial role in this context, allowing for the creation of highly accurate, dynamic virtual models that mirror the physical SSPCs in real-time. This talk explores an innovative approach to SSPC modeling that addresses these challenges. Our work introduces an electro-thermal-stress coupled model designed to support the development of virtual entities within a digital twin framework for SSPC systems. A practical device is taken as an example to illustrate the method of establishing the model and verify the effectiveness of the model.

DigiTwin 2024 Main-venue（ML-22)



Lorenzo RAGAZZINI

Assistant professor,
Politecnico di Milano (Italy)

Title:

Digital Twin-driven bottleneck prediction in manufacturing systems: enhancing performance through adaptive production control

Abstract

This research introduces a novel approach to bottleneck prediction based on Digital Twin, aiming to increase the performances of manufacturing systems through improved production control. The Digital Twin enables simulation of future system behavior, accounting for current conditions, which is then used to identify future bottlenecks. This predictive information guides production control decisions, adapting release and sequencing of the orders. The benefits of this approach are quantitatively evaluated, demonstrating enhanced system performance. This study bridges the gap between Digital Twin-based performance analysis and production control, offering valuable insights for researchers and industrial practitioners.

L Ragazzini, E Negri, L Fumagalli, M Macchi

DigiTwin 2024 Main-venue（ML-23)



Yiqi JIA

PhD student ,
Politecnico di Milano (Italy)

Title:

Digital Twin Framework for Advanced Fault Detection and Localization of Lithium-Ion Batteries

Abstract

The increasing demand for Lithium-ion batteries (LIBs) across various applications highlights the critical need to prioritize safety. In LIBs, where Internal Short Circuits (ISCs) serve as primary triggers for thermal runaway, the urgency of early detection becomes evident. Simultaneously, accurately localizing battery faults proves essential for targeted interventions, streamlining repairs, and minimizing potential risks. Based on the concept of a battery digital twin, our study offers a comprehensive model-based approach for detecting and localizing ISCs. By utilizing voltage and temperature measurements from our high-fidelity model (plant), a digital twin model (Equivalent Circuit Model (ECM)-thermal model) integrated into an advanced algorithm has been developed for easy application within the Battery Management System (BMS). This integration achieves online detection and localization of battery ISCs, as well as predictions for Remaining Useful Life (RUL) and State of Health (SOH). The digital twin concept creates a virtual replica of the physical battery system, enabling continuous real-time monitoring and prediction of battery behaviors. The overall framework enhances the model's predictive capabilities, ensuring heightened accuracy and efficiency in upholding the safety and reliability of LIBs. Furthermore, its applicability extends to battery packs, providing valuable insights into the spatial distribution of faults and enabling proactive maintenance strategies .

DigiTwin 2024 Main-venue（ML-24)



Yavar Taheri YEGANEH

PhD student ,
Politecnico di Milano (Italy)

Title:

Deep Learning Meets Active Inference for Digital Twin Applications in Energy-Efficient Control of Parallel Machines

Abstract

We investigate how deep learning can enable the application of active inference in developing energy-efficient control agents for manufacturing systems. Active inference, rooted in neuroscience, provides a unified probabilistic framework that integrates perception, learning, and action, with inherent uncertainty quantification. It also aligns with the digital twin philosophy, facilitating virtual representations of physical systems through an inferred model for improved decision-making. Our study explores deep active inference, an emerging field that combines deep learning with the active inference decision-making framework. By leveraging a deep active inference agent, we focus on controlling parallel and identical machine workstations to enhance energy efficiency. To address challenges posed by the stochastic nature of the problem and delayed policy responses, we introduce tailored enhancements to existing agent architectures. Specifically, we present multi-step transition and hybrid horizon methods to mitigate the need for complex planning. Our experimental results demonstrate the effectiveness of these enhancements and highlight the potential of the active inference-based approach for energy-efficient control in manufacturing systems.

Yavar Taheri Yeganeh, Mohsen Jafari, Andrea Matta

DigiTwin 2024 Main-venue（ML-25)



Chunxue Bai

Director of Shanghai Institute of Respiratory Disease, Doctoral Supervisor, Director of Lung Tumor Comprehensive Diagnosis and Treatment Center of Zhongshan Hospital (China)

Title:

Advances in metacosmic medicine

Abstract

Metaverse medicine is a rapidly growing field that applies digital technologies such as virtual reality (VR), augmented reality (AR), and blockchain to the healthcare industry. The development of meta-universe medicine has not only brought innovations in the way healthcare services are delivered, but has also reduced healthcare costs and improved accessibility and efficiency. With the continuous advancement of technology, healthcare services in the future will be more intelligent and humanized.

DigiTwin 2024 Main-venue（ML-26)



Peppino PAFFI

Chief of the 'Anaesthesia and Resuscitation'

P.O. San Francesco di Nuoro Hospital, of ASL Nuoro (Italy)

Title:

To be announced

Abstract

To be announced

DigiTwin 2024 Main-venue（ML-27)



Dedong Ma

Chief Physician, Professor, Doctoral supervisor
Qilu hospital of Shandong University (China)

Title:

Inhaled drug efficacy prediction based on digital twin technology

Abstract

With the continuous development of medical technology, inhaled medications have become an important means of treating respiratory diseases. A digital twin is a virtual copy of a physical entity or system in digital space, which realizes a true reflection of the real world state through real-time data acquisition and analysis. In the context of inhalation drug efficacy prediction, digital twins can help us simulate the behavior of drugs in the body and thus predict drug efficacy.

DigiTwin 2024 Sub-venue 1 (BJ)

Chair



Qinglin Qi

Associate Professor

Beihang University (China)

Co-Chair



Lukai SONG

Postdoctoral Fellow

The Hong Kong Polytechnic University (China)

Session on

DigiTwin 2024 Sub-venue 1 (Beijing)

Wednesday, October 16th 2024

Tencent ID: 525-153-053
https://meeting.tencent.com/dm/AZ0kiOvNsrYR

Milan Time	Beijing Time	Agenda
03:00	09:00	**BJ-1** Data-model Fusion: Model-based real-time prediction of surface roughness in fused deposition modeling with graph convolutional network-based error correction Yupeng WEI
03:30	09:30	**BJ-2** AI-driven system reliability framework and its application in aeroengine turbine blades Lu-Kai SONG
04:00	10:00	**BJ-3** Theory and Key Technologies of Digital Twin Model He ZHANG
04:30	10:30	**BJ-4** Digital twin satellite engineering: theories, technologies and applications Weiran LIU
05:00	11:00	**BJ-5** How to achieve the synchronization of digital twin? Xin MA
05:30	11:30	**BJ-6** Fleet state-aware aero-engine fleet collaborative maintenance Jiawei REN
08:00	14:00	**BJ-7** Operational Analysis and Supply and Demand Regulation towards Manufacturing Service Collaboration Platform Yanshan GAO
08:30	14:30	**BJ-8** Digital twin-based shop-floor reconfiguration design for uncertainty management Chenyuan ZHANG
10:00	16:00	**BJ-9** Data generation approach based on data model fusion: An application for rolling bearings fault diagnosis with small samples Yonghuai ZHU
10:30	16:30	**BJ-10** Deep Reinforcement Learning Based Clock Synchronization Method for Digital-physical Networks under Complex Dynamic Testing Circumstances Yanlong WANG
11:00	17:00	**BJ-11** The Research and Prospects of Scenarios Modeling for Aerospace Equipment's Data Reality Fusion Testing Pengfei GAO
11:30	17:30	**BJ-12** A product performance rapid simulation approach driven by digital twin data Lili DONG
12:00	18:00	**BJ-13** Research on disturbance identification and response methods for production line based on digital twins Qi MENG

DigiTwin 2024 Sub-venue 1（BJ-1)



Yupeng WEI

Associate Professor
Beihang University (China)

Title:

Data-model Fusion: Model-based real-time prediction of surface roughness in fused deposition modeling with graph convolutional network-based error correction

Abstract

Additively manufactured parts usually have relatively rough surface finish due to the layer-by-layer process. Extensive research has been conducted on the effect of process parameters on surface roughness as well as on real-time monitoring of surface roughness using sensor data. However, very few studies consider both process parameters and condition monitoring data to perform real-time prediction of surface roughness. To address this research gap, this work introduces an augmented deep learning framework that integrates a model-based predictor with a deep learning-based error corrector to predict the surface roughness of parts fabricated via fused deposition modeling. The model-based predictor predicts surface roughness by considering the effects of process parameters on surface roughness, while the deep learning-based error corrector estimates the prediction errors between the true surface roughness and predicted surface roughness using real-time sensor data collected during additive manufacturing. To consider both correlations among features extracted from sensor signals and temporal correlations of each sensor signal, we construct multiple graphs to reveal these correlations and introduce a multi-graph convolutional network to analyze these undirected graphs. Experimental results show that the proposed framework outperforms existing data-driven methods reported in the literature.

DigiTwin 2024 Sub-venue 1 （BJ-2)



Lu-Kai SONG

Postdoctoral Fellow

The Hong Kong Polytechnic University (China)

Title:

AI-driven system reliability framework and its application in aeroengine turbine blades

Abstract

For complex engineering systems characterized by multi-level subsystems and multi-class modules, leading to the traditional integral or separate reliability framework are prone to unacceptable efficiency or accuracy. In response to this problem, by fusing the advantages of AI computing tools into large-scale system theory, an AI-driven system reliability evaluation framework is presented. In this framework, the complex problem is decomposed into several distributed sub-problems (i.e., multi-variate, multi-disciplinary and multi-objective), and establishes the mutually nested AI-based sub-models for multivariate response mapping, multi-disciplinary static/dynamic collaboration and multi-objective reliability evaluation. A typical system reliability evaluation problem (i.e., aeroengine turbine blades) is taken to validate the presented theoretical framework.

DigiTwin 2024 Sub-venue 1 （BJ-3)



He ZHANG

Postdoctoral Fellow
Beihang University (China)

Title:

Theory and Key Technologies of Digital Twin Model

Abstract

As an effective means to realize the deep interaction and integration of virtual and physical worlds, digital twins have attracted much attention from academia, industry, finance, and government departments. According to the connotation and application of digital twins, high-fidelity models are the important foundation for digital twin implementation and important guarantee for providing correct and effective services. However, there lack all-round, holistic and systematic research on the theory and method of how to construct digital twin models accurately. Against the background, the relevant theories and methods of the key steps involved in the construction and use of digital twin models, including model construction, model assembly, model fusion, model verification, model update and model management, are studied respectively.

DigiTwin 2024 Sub-venue 1 （BJ-4)



Weiran LIU

Postdoctoral Fellow

Beihang University (China)

Title:

Digital twin satellite engineering: theories, technologies and applications

Abstract

Driven by the development of new technologies and diversified needs, the satellite industry has ushered in comprehensive and rapid development. The demands of digital transformation, the integration of new information technologies, the collaborative management of large and complex satellite projects, and satellite commercial services also pose new challenges to the satellite industry.

This presentation provides an overview of the current state of the satellite industry and analyzes its digital transformation needs. Based on this, the theories of digital twin satellite engineering are introduced, including the concept, architecture, key technologies and application framework of digital twin satellite engineering. Finally, the application explorations of digital twin satellite engineering in two scenarios: satellite mass assembly shop-floor and satellite communication network are introduced.

DigiTwin 2024 Sub-venue 1（BJ-5)



Xin MA

Postdoctoral Fellow

Beihang University (China)

Title:

How to achieve the synchronization of digital twin?

Abstract

Digital twin has made great strides with its widely applications in various fields. By enabling data interaction, digital twin mirrors real-time conditions of physical environments in a safe virtual space, allowing for dynamic decision-making. However, several critical challenges remain in implementing digital twin effectively. One key challenge is bridging the gap between physical and virtual spaces to achieve seamless synchronization. To address this problem, this presentation proposes a consistency method considering model evolution and data-model coupling. The feasibility of the proposed method has been validated through practical experience.

DigiTwin 2024 Sub-venue 1 （BJ-6)



Jiawei REN

PhD Student

Beihang University (China)

Title:

Fleet state-aware aero-engine fleet collaborative maintenance

Abstract

As the aviation industry continues to expand, the growth in both civilian and military fleets have positioned the maintenance of aero-engines as a critical area of research, driven by its paramount importance to safety and economic efficiency. To address the complexities of aero-engine fleet collaborative maintenance, this paper introduces a novel multi-element collaborative model that interlinks the flight plan, aero-engine fleet, and maintenance resources. We propose a fleet state-aware collaborative maintenance decision mechanism. With the perception of fleet state, proximal policy optimization (PPO) algorithm and maintenance urgency-aware mechanism are used to realize the decision-making of maintenance timing, maintenance objects, and maintenance actions.

The superiority and practical applicability of the proposed mechanism are demonstrated through simulation cases, which illustrate significant improvements in maintenance decision effect when compared to classical mechanisms. With the consideration of the interconnection of flight plan requirements, aero-engine health, and maintenance resource constraints, our model offers a robust framework for aero-engine fleet collaborative maintenance.

DigiTwin 2024 Sub-venue 1（BJ-7)



Yanshan GAO

PhD Student

Beihang University (China)

Title:

Operational Analysis and Supply and Demand Regulation towards Manufacturing Service Collaboration Platform

Abstract

Enhancing capacity utilization of manufacturing resources and capabilities is of utmost importance in tackling current manufacturing challenges of meeting customized and small-batch market demands. Given the research highlights on platform-based manufacturing service collaboration (MSC) offering

high-quality service solutions, effective operation and scheduling approaches are urgently needed to maximize the overall utility amidst great computational complexity and unpredictable operational fluctuations. For the batch processing of multiple tasks, to aggregate manufacturing services and optimize on-demand service collaboration in a distributed manner is a solution to ensure the robust and sustainable operation of the platform. This presentation proposes a set of theoretical methods for the operation analysis and supply-demand regulation of the platform-aggregated MSC, involving the comprehensive performance evaluation of collaborative operations, quick response to disturbances in collaboration processes, and adaptation to uncertainties in collaborative supply and demand.

DigiTwin 2024 Sub-venue 1（BJ-8)



Chenyuan ZHANG

PhD Student

Beihang University (China)

Title:

Digital twin-based shop-floor reconfiguration design for uncertainty management

Abstract

Reconfiguration has emerged as a paradigm that adjusts shop-floor operations based on production requirements in such a way as to obtain desired performance and adapt to changes quickly. However, uncertainty and complexity of shop-floor operations could diminish the effectiveness of the reconfiguration solution. This paper presents a digital twin-based design method for shop-floor reconfiguration to solve the problems. The proposed method is verified with the case study of a chemical fibre silk cake packing shop floor.

DigiTwin 2024 Sub-venue 1（BJ-9)



Yonghuai ZHU

PhD Student

Beihang University (China)

Title:

Data generation approach based on data model fusion: An application for rolling bearings fault diagnosis with small samples

Abstract

Utilizing fake data (simulated based on mechanism models or generated through data-driven models) for data enhancement is a popular approach to solve the problem of fault diagnosis with small samples. Consequently, the quality of such fake data impacts fault diagnosis accuracy. This paper proposes a data model fusion driven framework for small sample fault diagnosis. This framework integrates the digital twin model (DTM) and conditional deep convolutional generative adversarial networks (C-DCGAN). Digital twin data (DTD) under various fault conditions is first obtained in the data generation stage based on DTM simulation. Then, the method adopts DTD as the soft-physics constraint input to the generator of C-DCGAN. Hence, the generator is induced to generate data that is more consistent with the failure mechanism and closer to the real data. During the fault diagnosis stage, the generated data is used to enhance the training process of the fault diagnosis model, improving its generalization ability. Finally, the effectiveness of the proposed method is comprehensively verified via two publicly rolling bearing datasets.

DigiTwin 2024 Sub-venue 1 （BJ-10)



Yanlong WANG

PhD Student

Beihang University (China)

Title:

Deep Reinforcement Learning Based Clock Synchronization Method for Digital-physical Networks under Complex Dynamic Testing Circumstances

Abstract

The operation and testing of multi-type equipment currently require rigorous testing. Digital-physical fusion testing has the advantages of high performance and low cost compared with other testing methods, which need seamless communication between physical and digital spaces. Clock synchronization within digital-physical communication networks is crucial for maintaining consistency between the two spaces. However, existing clock synchronization methods have predominantly focused on physical nodes and failed to adequately account for the influence of dynamic environmental factors on synchronization accuracy. As a result, there exists a gap in effective clock synchronization architectures and methods for digital-physical networks. The proposed method establishes a composite clock model for digital nodes that considers the network load and various influence mechanisms of environments. Experiment results show the method's advantages in terms of synchronization accuracy, clock offset prediction accuracy and compensation stability under complex dynamic testing circumstances.

DigiTwin 2024 Sub-venue 1（BJ-11)



Pengfei GAO

PhD Student

Beihang University (China)

Title:

The Research and Prospects of Scenarios Modeling for Aerospace Equipment’ s Data Reality Fusion Testing

Abstract

In the current landscape of aerospace and advanced manufacturing, digital-physical fusion testing has the potential to enhance the reliability and functionality of equipment.. This report focuses on methods for constructing complex and diverse test scenarios, allowing for comprehensive testing of equipment performance, functionality, and algorithm reliability within a purely digital environment. By simulating diverse operational scenarios, digital-physical fusion testing enables rapid and cost-effective verification without the need for physical prototypes. The presentation will also explore the current development trends in data-driven 3D model construction and analyze advancements in fields such as AIGC and autonomous driving. These insights will help address the growing challenges and demands in the aviation sector, ultimately proposing a robust framework for generating testing scenarios tailored to aerospace equipment testing.

DigiTwin 2024 Sub-venue 1（BJ-12)



Lili DONG

PhD Candidate
Shandong University (China)

Title:

A product performance rapid simulation approach driven by digital twin data

Abstract

Finite element simulation, as a widely used performance analysis method, has a long simulation cycle, and high requirements on computer hardware performance, which leads to long product design and iteration time. Facing the performance analysis problem of configuration iteration and application conditions change in the process of product forward design, a product performance rapid simulation approach driven by digital twin (DT) data is studied, to replace the traditional finite element simulation method, and accelerate forward product design and iteration. This method makes full use of the finite element simulation and test bench data accumulated during the product iteration process as training data for the rapid simulation model, enabling complete performance verification for the entire process of typical continuous operating conditions within a relatively short period. It provides a practical and effective solution for shortening the iteration time and simplifying the verification process.

DigiTwin 2024 Sub-venue 1 （BJ-13)



Qi MENG

PhD Candidate
Shandong University (China)

Title:

Research on disturbance identification and response methods for production line based on digital twins

Abstract

As the manufacturing model evolves towards multiple varieties, small batches, and personalization, the transformation of production lines towards intelligence and modularization has become an inevitable trend. Since the production line is a complex system composed of a variety of processing equipment and process links, the existing production data lacks standardized expression, reconfiguration, and interaction capabilities, and is unable to quickly identify and effectively respond to disturbances in the production process. To address this problem, this report proposes a method for building a configurable digital twin data model for discrete manufacturing production lines, a method for identifying and responding to production process disturbances based on cloud-edge collaboration, and demonstrates the feasibility of the proposed method through actual cases.

DigiTwin 2024 Sub-venue 2 (PD)

Chair



Ragu Athinarayanan

Professor, School of Engineering Technology
Purdue University (United States)

Co-Chair



Martin Jun

Professor, School of Mechanical Engineering
Purdue University (United States)



Thorsten Wuest

Associate Professor, Industrial & Management Systems Engineering (IMSE) Department
Purdue University (United States)



Xingyu Li

Assistant Professor, School of Engineering Technology
Purdue University (United States)

Session on

DigiTwin 2024 Sub-venue 2 (Purdue University, US)

Tuesday, October 15th 2024

Tencent ID: 798-434-188
https://meeting.tencent.com/dm/SgbSCeXp1t2x

New York Time	Agenda
07:00 - 08:00	**PD Keynote-1** Digital Twin Enabled Life Cycle Inventory Modelling – Building the Data Foundation for Sustainable Manufacturing Prof. Fu Zhao, Mechanical Engineering and Environmental and Ecological Engineering, Purdue University
09:00 - 09:30	**TS-1** Fatigue Monitoring Using CVD Polymer-Coated Fabric Sensors for Foundry Safety Prof. Gaurav Nanda, School of Engineering, Purdue University
09:30 - 10:00	**TS-2** Digital Twin and AI Technologies for Design and Use of Manufacturing Equipment Mr. Prasad Satyavolu, Industry X Lead – Digital Manufacturing & Operations North America
10:00 - 10:30	**TS-3** The Use of a Digital Twin to Achieve Military Munitions Manufacturing Excellence Prof. Leon Lawrence Robert Jr., School of Chemical Engineering, Purdue University
12:30 - 13:30	**PD Keynote-2** Digital Twins: Accelerating the path to tomorrow Mark R. Beckmann
13:30 - 14:00	**TS-4** Crafting a Knowledge Graph and Ontology-based Manufacturing System Digital Twin for Interoperability Dr. Marvin May, MIT Visiting Scholar and KIT Chief Engineer Production System Planning
14:00 - 14:30	**TS-5** Efforts toward Enhancing Digital Twin Capability with Manufacturing Automation for Sustainability Dr. Chandra Nath, Senior Research Associate, Environmental and Ecological Engineering, Purdue University
14:30 - 15:00	**TS-6** Physics-Based Digital Twin for Hydraulic Equipment Prof. Leon Prof. Jose Garcia-Bravo, School of Engineering, Purdue University
15:00 - 15:30	**TS-7** Digital Twin: A Potential Platform for Enhancing Sustainability and Climate Resiliency in Agricultural and Food Sectors Prof. Suranjan Panigrahi, School of Engineering, Purdue University

Session on

DigiTwin 2024 Sub-venue 2 (Purdue University, US)

Wednesday, October 16th 2024

Tencent ID: 798-434-188
https://meeting.tencent.com/dm/SgbSCeXp1t2x

New York Time	Agenda
10:00 - 10:10	**SP-1** Physics-Based Digital Twin for Hydraulic Equipment Marvin Raymundo Durango Cogollo
10:10 - 10:20	**SP-2** Sustainable Management of Rare Earth Elements for Clean Energy Using Prescriptive Digital Twins MD Shafikul Islam
10:20 - 10:30	**SP-3** Stages of Integrating Digital Twin in Fused Deposition Modelling Azmine Toushik Wasi
10:30 - 10:40	**SP-4** Transforming Teleoperation through Immersive Digital Twins: A Collaborative Extended Reality (XR) Environment for Seamless Remote Operations Israa Azza
10:40 - 10:50	**SP-5** A Multi-Level Scheduling Approach for Enhancing Supply Chain Resilience Using Digitalization and Cloud Manufacturing Wei Ye
10:50 - 11:00	**SP-6** The Use of a Digital Twin to Achieve Military Munitions Manufacturing Excellence Leon Lawrence Robert Jr.
11:00 - 11:10	**SP-7** Digital twin and vision guided autonomous robotic path planning Jiho Lee
11:10 - 11:20	**SP-8** Generative AI based real-time human-data interaction for smart manufacturing Hojun Lee

DigiTwin 2024 Sub-venue 2(PD-1)



Prof. Fu Zhao

Head of DigiTwin Lab,
Purdue University

Title:

Digital Twin Enabled Life Cycle Inventory Modelling – Building the Data Foundation for Sustainable Manufacturing

Abstract

Life cycle assessment (LCA) has been widely recognised as the most objective tool to evaluate the environmental performance of a product or process. LCA recently has attracted increasing interest, in part because it is the underlying method to support carbon footprint reporting. LCA also finds applications in supporting design and development of environmentally friendly products and technologies, including features/processes that realize circular economy. Inventory analysis is a key step and data foundation of LCA-- it quantifies all the material and energy inputs and outputs involved in every process of the life cycle. However, data quality and availability at unit process level have been cited as the biggest challenges faced by LCA community. Current life cycle inventory (LCI) databases have serious shortcomings and limitations: they are usually static and outdated, carry large uncertainties, are rather generic (reflecting only representative or average industrial processes), and lack datasets on use phase and end of life management. Digital twin technologies create virtual replicates of physical assets by using high fidelity models and real time data collected from installed sensors. This opens up critical opportunities to advance LCI modeling. This talk will discuss the potential of using digital twins to address the major shortcomings and limitations of existing LCI modeling approaches as related to carbon footprint reporting at product level and green product/process development. Moreover, to apply digital twin based LCI modeling at supply chain or corporation level and to benefit the LCA community, algorithms and approaches that could enable proprietary information protection, data sharing, data validation, rewarding mechanisms are needed.

DigiTwin 2024 Sub-venue 2(PD-2)



Mark R. Beckmann

Sr. Director,
Worldwide Microsoft Manufacturing Industry Solutions

Title:

Digital Twins: Accelerating the path to tomorrow

Abstract

To be announced

DigiTwin 2024 Sub-venue 2(PD-3)



Ali Ahmad Malik

Assistant Professor,
Oakland University (US)

Title:

Enhancing Manufacturing Resilience Through Interoperability of Digital Twins

Abstract

To be announced

Digital Twin Smart Manufacturing I (SM1)



Chair

Haisong HUANG

Professor,

Guizhou University (China)



Co-Chair

Kai YANG

Associate Professor,

Guizhou University (China)

Session on

Digital Twin Smart Manufacturing I (SM1)

Wednesday, October 16th 2024

Tencent ID: 490-178-240
https://meeting.tencent.com/dm/tLe4USwgWC0t

Milan Time	Beijing Time	Agenda
10:00	16:00	**SM1-1** Advanced Manufacturing Empowered by Parallel Kinematic Machines Yan JIN
10:30	16:30	**SM1-2** End-to-End DRL for Path Planning on 3D Surfaces Ismael Lopez-JUAREZ
11:00	17:00	**SM1-3** Toward digital validation for smart manufacturing based on digital twin Sihan HUANG
11:30	17:30	**SM1-4** Using Digital Twin to Optimize Workforce Allocation and Improve Operation Efficiency in Smart Manufacturing with Discrete Event Simulation Alireza AHMADI
12:00	18:00	**SM1-5** Digital Twin for Sustainable and Resilient Supplier Management Yung Po TSANG

Digital Twin Smart Manufacturing I (SM1-1)



Yan JIN

Professor,
Queen's University Belfast (UK)

Title:

Advanced Manufacturing Empowered by Parallel Kinematic Machines

Abstract

Parallel robots have been intensively researched in the last three decades, but it is not widely utilized for manufacturing yet. This talk will introduce the state of the art of using parallel robots for high value manufacturing. Our latest research on automated aircraft assembly and double-sided synchronized machining using parallel kinematic machines will be presented. Research issues and future directions will be discussed.

Digital Twin Smart Manufacturing I (SM1-2)



Ismael Lopez-JUAREZ

Professor,

Center for Research and Advanced Studies (CINVESTAV), (Mexico)

Title:

End-to-End DRL for Path Planning on 3D Surfaces

Abstract

Deep Reinforcement Learning (DRL) is a robust learning paradigm that can be used to train agents through their interaction with the environment, but due to the sampling inefficiency of these algorithms, many computational resources and training time are needed to solve complex tasks, especially those based on computer vision.

The use of simulators to train agents promises to solve the training data demands of DRL algorithms. This, coupled with the extensive development of robotics simulators in the last decade (e.g., CoppeliaSim, MuJoCo, PyBullet) makes it a promising training approach. However, there are still bottlenecks in data exchange between the simulator and Deep Learning frameworks (e.g., TensorFlow, PyTorch), which delay training time.

A training methodology is presented that allows generating in simulation an optimized policy that solves the task of tracking trajectories on 3D surfaces, using only a partial observation of the environment (from an RGBD sensor) to derive the agent's actions (i.e., end- to-end), which also reduces the amount of time and computational resources needed for training. The objective is not to replace traditional control techniques for solving manipulation tasks. Instead, it is proposed to use a combination of DRL algorithms and traditional techniques to solve tasks with complex observation or action spaces. A reduction in training time is achieved with the proposed methodology, and the learned policy can follow three-dimensional trajectories with a small margin of error using only images from an RGBD sensor mounted on the robot’s end-effector.

Digital Twin Smart Manufacturing I (SM1-3)



Sihan HUANG

Associate Professor,
Beijing Institute of Technology (China)

Title:

Toward digital validation for smart manufacturing based on digital twin

Abstract

A digital validation framework of rapid product development for smart manufacturing based on digital twin is proposed. During product development, the new product is designed according to the new requirements in the virtual space, in which the existing digital twins of products can be referenced. Then, an ultrahigh-fidelity virtual manufacturing system is constructed for digital trial manufacturing based on the digital twin of the manufacturing system and the design scheme of the new product. An ultrahigh-fidelity digital prototype can be obtained from digital trial manufacturing for digital validation. The new product validation is executed on the digital proto- type to test its performance. The digital validation results can be used to improve the design scheme of the new product and boost the corresponding manufacturing processes. Finally, a case study is presented to show the effectiveness of the proposed framework.

Digital Twin Smart Manufacturing I (SM1-4)



Alireza AHMADI

PhD candidate,
Politecnico di Milano (Italy)

Title:

Using Digital Twin to Optimize Workforce Allocation and Improve Operation Efficiency in Smart Manufacturing with Discrete Event Simulation

Abstract

This study explores the use of Digital Twin technology combined with Labour Flexibility (LF) strategies and Discrete Event Simulation (DES) to enhance operational efficiency in Industry 5.0 manufacturing. By simulating various levels of worker flexibility, from static assignments to full cross-training, the impact on production performance is evaluated, particularly in terms of throughput time, worker relocation, and resource usage. Results indicate that moderate flexibility reduces idle time, while excessive flexibility can lead to diminishing returns. The Digital Twin facilitates real-time monitoring and predictive analytics, ensuring efficient workforce allocation to meet bottlenecks. Integrating this system with Manufacturing Execution Systems (MES) enhances communication between digital and physical assets. This research highlights how smart manufacturing can achieve operational excellence and human-centric adaptability through digital transformation.

Digital Twin Smart Manufacturing I (SM1-5)



Yung Po TSANG

Lecturer,
The Hong Kong Polytechnic University (China)

Title:

Digital Twin for Sustainable and Resilient Supplier Management

Abstract

In the era of Industry 4.0, conventional supplier management practices struggle with uncertainty and lack effective decision validation. This research introduces a decision support system that addresses these challenges by integrating stratified decision-making with multi-agent digital twin technology. The digital twin enables real-time simulation and validation of supplier development strategies, enhancing adaptability and resilience.

Digital Twin Smart Manufacturing II （SM2）

Chair



Guohong DAI

Professor, President

Jiangsu University of Technology (China)

Co-Chair



Patrick Ruediger-Flore

Professor

Department of Mechanical and Process Engineering of RPTU (Germany)



Yuan CHAO

Associate Professor

Jiangsu University of Technology (China)



Chao TAN

Lecturer

Jiangsu University of Technology (China)

Session on

Digital Twin Smart Manufacturing II (SM2)

Wednesday, October 16th 2024
Tencent ID: 479-167-293
https://meeting.tencent.com/dm/5mOfTbK4xVhm

Milan Time	Beijing Time	Agenda
10:00	16:00	**SM2-1** Revolutionizing Smart Manufacturing and Future Workforce through Integration of Haptic Bilateral Exoskeleton Gloves and Virtual Reality in Robot Control Lin JIANG
10:30	16:30	**SM2-2** Robot intelligent manufacturing technology in complex working conditions Lang XU
11:00	17:00	**SM2-3** Explainable Modeling for Equipment Fault Diagnosis Driven by Non-Ideal Operation and Maintenance Data in the Context of Digital Twin Guohong DAI
11:30	17:30	**SM2-4** Digital twin based human-robot collaboration in intelligent disassembly of electric-vehicle batteries for sustainable manufacturing Long BAI
12:00	18:00	**SM2-5** An intelligent system proposal for micro electrochemical machining based on sensor-integrated electrodes Guodong LIU
15:00	21:00	**SM2-6** Evolutionary Optimization Methods for High-dimensional Expensive Problems Meiji CUI
15:30	21:30	**SM2-7** Condition monitoring of micro drill based on digital twin in the PCB drilling process Qifeng TAN
16:00	22:00	**SM2-8** Research on a fast performance prediction method of grain combine harvesters based on digital twin Yang LI
16:30	22:30	**SM2-9** An accurate fatigue life calculation method on cycloidal gear of RV reducer based on finite element analysis Zhenhua HAN
17:00	23:00	**SM2-10** HOA-MPC Control Investigation for Hub-Motor Electric Vehicles with Air Suspension based on Road Roughness identification Ying ZHOU
17:30	23:30	**SM2-11** Digital twin based intelligent assembly for 3C tiny screws Hengyu LU

Digital Twin Smart Manufacturing II (SM2-1)



Lin JIANG

Associate Professor,
Charles W. Davidson College of Engineering, San Jose State University (USA)

Title:

Revolutionizing Smart Manufacturing and Future Workforce through Integration of Haptic Bilateral Exoskeleton Gloves and Virtual Reality in Robot Control

This research aims to revolutionize Smart Manufacturing and the future workforce by integrating Haptic Bilateral Exoskeleton Gloves and Virtual Reality into robot control, leveraging recent advances in virtual reality technology. The goal is to establish an immersive VR system, using wearables like haptic gloves and VR suits to bridge the physical and cyber worlds. The proposal introduces an augmented tactile-perception and haptic-enabled exoskeleton wearable, enhancing interactions across real and virtual realms. Three key research activities include designing prototypes, utilizing collaborative robots for replicating workplace tasks, and enabling haptic cues for robot teleoperation. This initiative not only promises to redefine workplace interactions but also addresses global manufacturing demands, reducing strain on resources and empowering Industrial 5.0.

Digital Twin Smart Manufacturing II (SM2-2)



Lang XU

Professor,
Chongqing University (China)

Title:

Robot intelligent manufacturing technology in complex working conditions

Abstract

The efficient and high-quality construction of major national projects is related to the development of the national economy. With the increase in the scale of the project, the traditional construction mode in the high-altitude location will bring big construction safety risks, low construction efficiency and difficult to guarantee the project quality. Therefore, parts manufacturing and construction assembly are reshaping the construction mode of major national projects. However, the existing manufacturing mode of parts relies on a large number of manual and simple machinery, due to the large size of parts, heavy loads, complex processes, various specifications, and poor manufacturing environment, it is difficult to ensure the consistency of major engineering parts, can not meet the assembly requirements. Therefore, robotized intelligent manufacturing is the key to ensuring the high quality of major national projects. The team broke through the feature recognition and precise positioning technology in complex manufacturing scenarios, the control method of multi-source disturbance to increase stability and reduce swing, and the production planning and scheduling algorithm in complex working conditions, and formed the robotized manufacturing technology system of steel bar pieces, which was applied to the construction of many bridges.

Digital Twin Smart Manufacturing II (SM2-3)



Guohong DAI

Professor,
President of Jiangsu University of Technology (China)

Title:

Digital twin-based human-robot collaboration in intelligent disassembly of electric-vehicle batteries for sustainable manufacturing

Abstract

With the development of electric-vehicles, research on disassembly of electric-vehicle batteries is of critical importance for resource recycling. This study devotes to the intelligent disassembly of electric-vehicle batteries by applying digital twin technologies to robots. By introducing the digital twin framework, the theory of intelligent manufacturing can be enhanced, and the safety of workers can be guaranteed. The goal of this research is to present a novel human-robot collaboration architecture for intelligent disassembly, using computer vision-based online detection and force telepresence-based human-robot interaction. The contributions include establishing a mapping relationship between reality and virtuality for the robot disassembly platform, multi-scale object detection and pose estimation, force perception and transmission in non-contact states, robot self-learning and autonomous mission planning. This report is dedicated to leveraging the digital twin theory and intelligent manufacturing approaches to achieve the safe and sustainable manufacturing of electric-vehicle batteries so as to promote the realization of carbon neutrality.

Digital Twin Smart Manufacturing II (SM2-4)



Long BAI

Associate Professor,
Huazhong University of Science and Technology (China)

Title:

Digital Twin-Enhanced Surface Roughness Prediction in Ultra-Precision Machining: A Hybrid Physics-Data-Driven Approach

Abstract

Achieving superior surface finish quality is paramount for the optimal performance of machined components, and single-point diamond ultra-precision machining has proven effective in attaining exceptional surface quality across a wide range of engineering materials. This research explores the challenge of forecasting surface roughness for titanium alloy workpieces subjected to ultra-precision machining by leveraging a digital twin approach. Experimental data encompassing process parameters and surface roughness measurements were collected during end-face machining trials and used to develop a high-fidelity digital twin of the machining process. Leveraging the ResNet-50 architecture, a deep learning neural network model was integrated into the digital twin to predict surface roughness. In an effort to enhance prediction accuracy, we introduce the energy ratio difference (ERD) as a stability feature, which can be derived using fast iterative variational mode decomposition (FI-VMD) within the digital twin framework. Additionally, the roughness value obtained from an analytic model was incorporated as an input feature for the prediction model. The inclusion of these two novel roughness predictors resulted in an 8.7% improvement in prediction accuracy for the proposed digital twin approach. Furthermore, the impact of tool parameters on prediction accuracy was examined, revealing that the proposed hybrid-driven digital twin model demonstrated superior robustness to tool parameter errors compared to the analytic roughness model. The digital twin's ability to accurately predict surface roughness enables more efficient process optimization and quality control in ultra-precision machining.

Digital Twin Smart Manufacturing II (SM2-5)



Guodong LIU

Associate research fellow,
Beijing Institute of Technology (China)

Title:

An intelligent system proposal for micro electrochemical machining based on sensor-integrated electrodes

Abstract

Aiming at the fundamental process-related issues such as poor machining localization and unclear inter-electrode processing status restricting the development of micro electrochemical machining (ECM), a novel micro ECM system based on the sensors-integrated silicon electrode is proposed. Based on MEMS manufacturing technology, the sensors-integrated silicon electrode is firstly designed and fabricated for in-situ detection of status signals of electrolyte temperature, conductivity, and so on. Based on the multi-state signal fusion analysis, the processing status detection model can be established to accurately control machining gaps. A novel multiphysics simulation enabled 'virtual sensing' approach is proposed to validate the chip-on-tool-based monitoring results..

Digital Twin Smart Manufacturing II (SM2-6)



Meiji CUI

Associate Professor,
Nanjing University of Science and Technology (China)

Title:

Evolutionary Optimization Methods for High-dimensional Expensive Problems

Abstract

Evolutionary computation is a rapidly evolving field and the related algorithms have been successfully used to solve various real-world optimization problems. The past decade has also witnessed their fast progress to solve a class of challenging optimization problems called high-dimensional expensive problems (HEPs). The evaluation of their objective fitness requires expensive resource due to their use of time-consuming physical experiments or computer simulations. Moreover, it is hard to traverse the huge search space within reasonable resource as problem dimension increases. Traditional evolutionary algorithms tend to fail to solve HEPs competently because they need to conduct many such expensive evaluations before achieving satisfactory results. To reduce such evaluations, many novel surrogate-assisted algorithms emerge to cope with HEPs in recent years. Yet there lacks a thorough review of the state of the art in this specific and important area. This report provides a comprehensive survey of these evolutionary algorithms for HEPs. We start with a brief introduction to the research status and the basic concepts of HEPs. Then, we present surrogate-assisted evolutionary algorithms for HEPs from four main aspects. We also give comparative results of some representative algorithms and application examples. Finally, we indicate open challenges and several promising directions to advance the progress in evolutionary optimization algorithms for HEPs.

Digital Twin Smart Manufacturing II (SM2-7)



Qifeng TAN

Associate Professor,
Jiangsu University of Technology (China)

Title:

Condition monitoring of micro drill based on digital twin in the PCB drilling process

Abstract

The wear of micro drill in the PCB drilling process will lead to the degradation of drilling quality. Aiming at the drilling quality control, we propose a real-time monitoring method of drill condition based on digital twin, and build a digital twin system of high-speed drilling machine tool for real-time monitoring of drill wear. With the support of key technologies such as digital space scene construction, multi-source heterogeneous data transmission and management, machining process mapping, tool state analysis and prediction, data visualization, etc., the real-time, intelligent and transparent control of the drilling process has been accomplished, realizing real-time monitoring and control of the micro drill wear in the PCB drilling process.

Digital Twin Smart Manufacturing II (SM2-8)



Yang LI

Associate Professor,
Jiangsu University of Technology (China)

Title:

Research on a fast performance prediction method of grain combine harvesters based on digital twin

Abstract

The threshing and cleaning devices are critical components of the harvester's digestive system and play a pivotal role in determining overall operational performance. Therefore, optimizing the performance of these devices is crucial. Currently, traditional design methods for these often rely on empirical design combined with bench tests or prototype machines for validation. However, this approach consumes significant resources in terms of manpower and time. In response to these issues, this study proposes a rapid simulation method based on digital twin model driving. The proposed method involved designing sensor monitoring schemes to represent the devices' performance followed by collecting field test data under various operating conditions. Subsequently, the CFD/CFD-DEM numerical simulations were employed to explore effective methods for representing device performance. Finally, integrating multi-source sensor data with numerical simulation data and theoretical parameter analysis enabled the construction of a digital twin model for the threshing and cleaning devices. The accuracy and efficiency of this model were then verified. This methodology allows for efficient verification of threshing and cleaning device performance across typical working conditions within a short timeframe. As such, it provides an effective solution for reducing product iteration time while saving on design costs.

Digital Twin Smart Manufacturing II (SM2-9)



Zhenhua HAN

Associate Professor,
Jiangsu University of Technology (China)

Title:

An accurate fatigue life calculation method on cycloidal gear of RV reducer based on finite element analysis

Abstract

RV(rotate vector) reducer is crucial in precision transmission equipment such as industrial robot joints, CNC machine tool turrets, and semiconductor manufacturing equipment. Cycloidal gear pair is vital for achieving high precision transmission performance in RV reducer due to their high reduction ratio, compact size and high efficiency. Digital twin technology has irreplaceable advantages in the monitoring of equipment throughout its entire service life. Therefore, for implementing digital twin technology to monitor the lifecycle of RV reducer, an accurate calculation method on the fatigue life of cycloidal gear is critical. However, traditional analytical methods assume linear deformation conditions for cycloidal gear contact mechanics, which cannot accurately reflect the mechanical behavior of cycloidal gear under load. As a result, there is a significant difference between actual service life and calculated fatigue life. This study introduces an effective method for evaluating the fatigue life of cycloidal gear. A load tooth contact model for cycloidal gear pair is established using ABAQUS software. By applying rotation to pin gear housing and load torque to cycloidal gear as boundary conditions, a multi-load step static analysis is conducted using the Newton-Raphson algorithm within ABAQUS/Standard. The distribution and maximum values of contact stress in the gear pair are calculated. Finally, the accurate fatigue life of cycloidal gear is calculated by combining stress results from finite element analysis with load time history of cycloidal gear. The Miner linear damage rule and Fe-safe software are employed for this calculation. This approach establishes a foundation for developing a digital twin model and implementing intelligent manufacturing of RV reducer.

Digital Twin Smart Manufacturing II (SM2-10)



Ying ZHOU

Ph.D Candidate,
Jiangsu University (China)

Title:

HOA-MPC Control Investigation for Hub-Motor Electric Vehicles with Air Suspension based on Road Roughness identification

Abstract

As electric vehicle propulsion systems have matured to meet consumer expectations, the focus has shifted to enhancing vertical dynamics and comfort. The suspension systems and hub-motor setups has provided valuable insights for selecting the right system to mitigate unbalanced electromagnetic force (UEMF) in hub-motor electric vehicles (HMEVs). This study introduces a Heron Optimization Algorithm-Model Predictive Control (HOA-MPC) strategy for hub-motor electric vehicles equipped with air suspension (HM-AS), aiming to enhance ride comfort, handling stability, and reduce eccentricity between the stator and rotor. A full-vehicle dynamic model considering vertical-longitudinal coupling is established and validated. A road surface identification system based on a Physics-informed neural network (PINNs) is designed. The Self-Organizing Map (SOM) is used to optimize weight coefficients on 16 conditions, which are then saved as tables for HOA-MPC. An HOA-MPC controller is designed based on distributed prediction model, which decompose the entire vehicle into four subsystems and consider the coupling of roll and pitch. Simulation results demonstrated that HOA-MPC achieves improvements of 25% in body acceleration, 16% in eccentricity, 5% in tire dynamic load, 25% in roll, and 15% in pitch. It showcases its effectiveness in enhancing ride comfort and vehicle stability.

Digital Twin Smart Manufacturing II (SM2-11)



Hengyu LU

Postgraduate student,
Jiangsu University of Technology (China)

Title:

Digital twin based intelligent assembly for 3C tiny screws

Abstract

With the development of technology and intelligent manufacturing, 3C devices play an important role in life. Intelligent assembly for screws is the key to ensuring efficient production. This study applies digital twin technology to robot intelligent assembly of 3C devices. By introducing the digital twin framework, the real-time assembly data is accurately transmitted to the virtual model, enabling virtual debugging of robot assembly, saving production resources and improving production efficiency. The goal of this study is to present a digital twin based intelligent assembly system for 3C devices production lines. The contributions include establishing a digital twin system for mapping real and virtual environments of the robot assembly platform, enabling real-time data exchange between the virtual and physical environments. The data of screw semantic segmentation is transmitted to the digital twin system, which autonomously plans tasks for the robot. This study integrates digital twin theory and intelligent manufacturing approaches to achieve intelligent production of 3C devices, further promoting the development and advance of the manufacturing industry.

Digital Twin Smart Manufacturing III (SM3)

Chair



Shimin LIU

Postdoctoral fellow

Hong Kong Polytechnic University (China)

Co-Chair



Zheng PAI

Associate Professor

Hong Kong Polytechnic University (China)

Session on

Digital Twin Smart Manufacturing III (SM3)

Wednesday, October 16th 2024

Tencent ID: 276-671-904
https://meeting.tencent.com/dm/MfRUUc83I4Vq

Milan Time	Beijing Time	Agenda
10:00	16:00	**SM3-1** Digital twin-driven Human-Robot Collaborative Disassembly Sequence Planning with Large Language Models in Remanufacturing Liqiao XIA
10:30	16:30	**SM3-2** Smart Manufacturing for Ultra-Precision Machining (UPM) Technology Zhicheng XU
11:00	17:00	**SM3-3** Explainable Modeling for Equipment Fault Diagnosis Driven by Non-Ideal Operation and Maintenance Data in the Context of Digital Twin Jianan WEI
11:30	17:30	**SM3-4** A multi-agent and cloud-edge orchestration framework of digital twin for distributed production control Qingwei NIE
12:00	18:00	**SM3-5** MetaTwin: Enhancing Digital Twin with Fine-Grained Decomposition and Cross-Scale Assembly Xiaojian WEN
15:00	21:00	**SM3-6** Digital Twin-Enabled Task Planning and Allocation Approach for Human-Robot Collaborative Assembly Yaqian ZHANG
15:30	21:30	**SM3-7** Exploring Mixed Reality's Role in Deep Reinforcement Learning for Safe Human-Robot Motion Generation Chengxi LI
16:00	22:00	**SM3-8** Research on Digital Twin Temporal Intelligent Agent Based on Large Language Model Yicheng SUN
16:30	22:30	**SM3-9** An Adaptive Dynamic Digital Twin Approach for Product Performance Optimization Xinyu LIU
17:00	23:00	**SM3-10** Digital twins- based Multi-Robot Machining Method for Cabin-Like Components Haozhi XIONG
17:30	23:30	**SM3-11** TransK-CNN: Convolution based on kernel fused transformer for artery vein classification in fundus images Yanfeng KUANG

Digital Twin Smart Manufacturing III (SM3-1)



Liqiao XIA

Professor

Case Western Reserve University (USA)

Title:

Digital twin-driven Human-Robot Collaborative Disassembly Sequence Planning with Large Language Models in Remanufacturing

Abstract

Human-robot collaborative disassembly (HRCD) is a promising approach in remanufacturing, leveraging robot's efficiency and human's adaptability for disassembling end-of-life (EoL) products. However, HRCD often encounters numerous choices with uncertain outcomes, posing significant challenges. To address this issue, an HRCD sequence planning digital twin model is introduced, providing a quantitative analysis of various decisions with explanations. Initially, HRCD constraint graph is constructed for targeted EoL product based on semantic documents. Subsequently, a Dirichlet Bayesian Network (DiBN) is employed to generate feasible sequences based on the HRCD constraint graph, effectively quantifying uncertainty. Then, a fine-tuned large language model with tailored prompts is utilized to quantitatively analyze the DiBN-based sequences. The DiBN is updated with high-performing sequences from LLM, mitigating the limited knowledge about specific EoL products. Furthermore, a Generative Adversarial Network is proposed to integrate the aforementioned modules for effective training. The effectiveness of the proposed digital twin model is demonstrated through two HRCD case studies.

Digital Twin Smart Manufacturing III (SM3-2)



Zhicheng XU

Professor

The Hong Kong Polytechnic University (China)

Title:

Smart Manufacturing for Ultra-Precision Machining (UPM) Technology

Abstract

In the wave of Industry 4.0 and smart manufacturing, ultra-precision machining technology is rapidly evolving to achieve higher quality, machinig efficiency, and energy savings. This course will introduce the application of the Internet of Things (IoT) and deep learning in ultra-precision machining by developing a digital twin system for real-time monitoring and analyzing energy comsumption characteristic of the machining process. With the digital twin technology, virtual models and simulations of the machining process will be explored to optimize process parameters for reducing the energy comsumprtion and achieve dynamic error compensation for higer product accuracy. In the end, the prospective of future ultra-precision machining system will be discussed.

Digital Twin Smart Manufacturing III (SM3-3)



Jianan WEI

Professor

Guizhou University (China)

Title:

Explainable Modeling for Equipment Fault Diagnosis Driven by Non-Ideal Operation and Maintenance Data in the Context of Digital Twin

Abstract

The digital twin process for intelligent maintenance of high-end equipment is progressing rapidly. However, due to the complexity of data collection environments and harsh operating conditions, real-time health data exhibit typical characteristics of small sample, heterogeneous, and imbalanced data. This poses significant challenges for explainable fault modeling in high-end equipment Prognostics and Health Management (PHM). This report uses explainable fault modeling of components such as bearings, tools, gears, and rotors within the digital twin framework as examples. It focuses on the treatment ideas, theories, technologies, and applications of several types of heterogeneous and imbalanced small sample maintenance data, and also explores future research directions. The findings play a crucial role in revealing the evolutionary patterns of explainable fault diagnosis modeling with small samples and provide theoretical and technical support for related fields.

Digital Twin Smart Manufacturing III (SM3-4)



Qingwei NIE

Doctor

Yangzhou University (China)

Title:

A multi-agent and cloud-edge orchestration framework of digital twin for distributed production control

Abstract

The demands for mass individualization and networked collaborative manufacturing are increasing, bringing significant challenges to effectively organizing idle distributed manufacturing resources. To improve production efficiency and applicability in the distributed manufacturing environment, this paper proposes a multi-agent and cloud-edge orchestration framework of digital twin for production control. A multi-agent system is established both at the cloud and the edge to achieve the operation mechanism of cloud-edge orchestration. By leveraging Digital Twin technology and Industrial Internet of Things, real-time status data of the distributed manufacturing resources are collected and processed to perform the decision-making and manufacturing execution by the corresponding agent with permission. Based on the generated data of distributed shopfloors and factories, the cloud production line model is established to support the optimal configuration of the distributed idle manufacturing resources by applying a systematic evaluation method and digital twin technology, which reflects the actual manufacturing scenario of the whole production process. In addition, a rescheduling decision prediction model for distributed control adjustment on the cloud is developed, which is driven by Convolutional Neural Network combined with Bi-directional Long Short-Term Memory and attention mechanism. A self-adaptive strategy that makes the real-time exceptions results available on the cloud production line for holistic rescheduling decisions is brought to make the distributed manufacturing resources intelligent enough to address the influences of different degrees of exceptions at the edge. The applicability and efficiency of the proposed framework are verified through a design case.

Digital Twin Smart Manufacturing III (SM3-5)



Xiaojian WEN

Doctor

Donghua University (China)

Title:

MetaTwin: Enhancing Digital Twin with Fine-Grained Decomposition and Cross-Scale Assembly

Abstract

Digital twin technology has emerged as a powerful paradigm in the field of manufacturing, enabling virtual representations of physical assets and processes. However, the current state-of-the-art digital twin systems often face challenges in effectively capturing and representing complex systems with diverse scales and levels of granularity. To address these limitations, this paper proposes MetaTwin, a novel approach that enhances digital twin capabilities through fine-grained decomposition and cross-scale assembly. MetaTwin introduces a hierarchical structure that allows for the decomposition of a digital twin into smaller, more manageable components, each representing a specific aspect or subsystem of the physical system. This fine-grained decomposition enables greater flexibility in modeling and simulation, allowing for the representation of complex systems at different levels of detail. Additionally, MetaTwin incorporates a cross-scale assembly mechanism that facilitates the seamless integration of these decomposed components, enabling the creation of digital twins that span multiple scales and levels of granularity.

Digital Twin Smart Manufacturing III (SM3-6)



Yaqian ZHANG

PhD Researcher

Institute of Smart Manufacturing Systems, Chang'an University (China)

Title:

Digital Twin-Enabled Task Planning and Allocation Approach for Human-Robot Collaborative Assembly

Abstract

For human-robot collaborative assembly, current research often prioritizes efficiency while neglecting the management of operator fatigue risks. To address this issue, this study proposes a digital twin framework and operational system specifically designed for human-robot collaborative assembly. Furthermore, with the optimization objectives of minimizing cycle time and reducing operator fatigue, a digital twin-enabled task planning and allocation method for human-robot collaborative assembly is proposed.

Digital Twin Smart Manufacturing III (SM3-7)



Chengxi LI

Doctor

The Hong Kong Polytechnic University (China)

Title:

Exploring Mixed Reality's Role in Deep Reinforcement Learning for Safe Human-Robot Motion Generation

Abstract

With the advent of Industry 5.0, the manufacturing landscape has shifted towards a human-centric paradigm, necessitating interactive assistance from manufacturing equipment, such as robots, to tackle dynamic and complex production tasks. Achieving symbiotic human-in-the-loop activities requires a robust foundation of safety measures. However, as manufacturing tasks become increasingly individualized, conventional rule-based approaches to ensure safety fall short due to their inflexibility and lack of synergy. To address this gap, our study presents a novel mutual-cognitive safe interaction approach by leveraging Mixed-Reality devices and Reinforcement Learning. This approach integrates key elements including worker visual augmentation, robot velocity control, Digital Twin-enabled motion preview, collision detection, and Deep Reinforcement Learning-based robot collision avoidance motion planning, all facilitated through Mixed Reality technology. By combining these components, the proposed approach aims to enhance safety while enabling effective interaction and collaboration.

Digital Twin Smart Manufacturing III (SM3-8)



Yicheng SUN

Doctor

Donghua University (China)

Title:

Research on Digital Twin Temporal Intelligent Agent Based on Large Language Model

Abstract

Digital Twin (DT), as an efficient technology for virtual-physical interaction, has demonstrated significant application potential in various industries. Intelligent agent-driven digital twin systems excel in analysis, decision-making, and control, making them highly suitable for manufacturing resource scheduling, diagnostic decision-making, and other requirements. However, current intelligent agents have notable deficiencies in adaptability, data utilization, and interpretability. This limitation undermines decision security and acceptability, creating barriers for user intervention. Therefore, we introduce a DT multi agent architecture driven by Large Language Models (LLMs). Agents perceive the characteristics of physical systems, particularly their temporal characteristics, by integrating data from various modalities. Multiple agents achieve insights through specific interaction mechanisms, while maintaining traceability. To showcase the advantages and characteristics of this architecture, we developed a typical application scenario for equipment maintenance.

Digital Twin Smart Manufacturing III (SM3-9)



Xinyu LIU

Doctor

School of Engineering, Ocean University of China (China)

Title:

An Adaptive Dynamic Digital Twin Approach for Product Performance Optimization

Abstract

Digital twin has been gradually explored and applied in the field of product intelligent optimization. As a technology that maps physical entities to virtual domains, digital twin optimization models can be constructed to update and solve the model in response to the change in operation state. However, the correlation between the updated model and the original model is not considered in the above process, and the updated model needs to be re-solved. This leads to the poor adaptability of the current method. Therefore, this paper proposes an adaptive dynamic digital twin approach for product performance optimization. By constructing the DT optimization model based on the Gradient Boosting Regression Trees (GBRT), which can infer and update the mapping relationships between the parameters and indicators to be optimized. Subsequently, a dynamic optimization strategy based on Adaptive Non-dominated Sorting Genetic Algorithm (Ad-NSGA) is proposed. Based on the evaluation of the degree of model correlation, it realizes the dynamic update of the population and adaptive search for optimization. Finally, the effectiveness of this approach is verified through a case study on the bogie system, which has better adaptability in dynamic optimization.

Digital Twin Smart Manufacturing III (SM3-10)



Haozhi XIONG

Postgraduate student
Wuhan University of Science and Technology (China)

Title:

Digital twins- based Multi-Robot Machining Method for Cabin-Like Components

Abstract

As an important component of aerospace equipment such as missiles, rockets and satellites, there are many complex intersecting characteristics and narrow feasible space inside the cabin components, which bring great challenges to the processing of its inner wall. The processing efficiency and intelligence level of manufacturing equipment are difficult to meet the rapid and high-quality development needs of aerospace equipment. To improve the machining efficiency and intelligent level of cabin component manufacturing equipment, a multi-robot intelligent collaborative machining method based on digital twin was proposed. The digital twin framework of virtual space, physical space and information data layer of robot collaborative processing system with different functions is constructed. The design of twin data model such as twin data source and type, data fusion and data storage is elaborated in detail. The optimal control and decision-making model of multi-robot collaborative processing is established. The software and hardware platform of multi-robot intelligent processing is developed. The virtual-real mapping and interaction are realized, and the on-line monitoring of processing system is realized. Taking the precision milling and measurement process of a certain type of aircraft cabin as a case for verification and analysis, the processing route is optimized, the processing efficiency is improved, and the feasibility and efficiency of the method are verified.

Digital Twin Smart Manufacturing III (SM3-11)



Yanfeng KUANG

Postgraduate student

Wuhan University of Science and Technology (China)

Title:

TransK-CNN: Convolution based on kernel fused transformer for artery vein classification in fundus images

Abstract

The early screening of the retina can effectively prevent certain diseases, and the segmentation of blood vessels in fundus images can enhance the efficiency of screening. However, further segmenting these blood vessels into arteries and veins poses a more complex challenge. While numerous scholars have proposed some deep learning methods for fundus vessel segmentation, most of these approaches primarily focus on convolutional methods which are insensitive to pixel relationships. To address this limitation, this paper proposes a unique approach that combines both convolutional kernels and transformers. Unlike other methods that combine these two techniques, our attention mechanism is calculated within the convolutional kernel framework to overcome the computational limitations associated with transformers in image analysis tasks. The proposed method is validated on the RITE and HRF datasets. Moreover, the RITE dataset achieved a sensitivity of 0.9698, specificity of 0.9491, accuracy of 0.9604, and F1 index of 0.9647. Similarly, the HRF dataset yielded impressive scores with a sensitivity of 0.9797, specificity of 0.9726, accuracy of 0.9765, and F1 index of 0.9785.

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)

Session on

Digital Twin Interdisciplinary Frontiers I (IF1)

Wednesday, October 16th 2024

Tencent ID: 258-451-103
https://meeting.tencent.com/dm/aZTWb59r0My4

Milan Time	Beijing Time	Agenda
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（IF1-1）



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.

DT Interdisciplinary Frontiers II (IF2)

Chair



Fei TAO

Professor

Beihang University (China)

Co-Chair



Nabil ANWER

CIRP Fellow, AET Fellow

Paris-Saclay University (France)



Qinglin QI

Associate Professor

Beihang University (China)

Session on

Digital Twin Interdisciplinary Frontiers II (IF2)

Tuesday, October 15th 2024

Tencent ID: 886-136-546
https://meeting.tencent.com/dm/CidqZkYBICYh

Milan Time	Beijing Time	Agenda
14:00	20:00	**IF2-1** Advanced Robust Model Predictive Control (MPC) Framework for Autonomous Intelligent Mechatronic Systems Yang SHI
14:30	20:30	**IF2-2** Digital twin of manufacturing processes for enhanced process stability and efficiency Jun QIAN
15:00	21:00	**IF2-3** Trustworthy AI-based Solutions for Industrial Machine Condition Monitoring Min XIA
15:30	21:30	**IF2-4** Convergence of AI, Physics, and Computing for Intelligent Emergency Control in Large-Scale Power Systems Qiuhua HUANG
16:00	22:00	**IF2-5** Predictive digital twin-driven dynamic error control for ultra-precision machining: A Case study in slow-tool-servo ultra-precision diamond turning Qi LIU
16:30	22:30	**IF2-6** Deep Audio-Visual Speech Recognition Pingchuan MA
17:00	23:00	**IF2-7** Diagnose Like a Radiologist: Hybrid Neuro-Probabilistic Reasoning for Attribute-Based Medical Image Diagnosis Gangming ZHAO
17:30	23:30	**IF2-8** Ensemble Learning-Based Stability Improvement Method for Feature Selection towards Performance Prediction Yulong ZHAO

DT Interdisciplinary Frontiers II (IF2-1)



Yang SHI

Professor,
IEEE, ASME, EIC, CSME Fellow, University of Victoria (Canada)

Title:

Advanced Robust Model Predictive Control (MPC) Framework for Autonomous Intelligent Mechatronic Systems

Abstract

Networked and distributed control for mechatronic systems have received great attention in the control community due to its wide application areas. Network-induced limitations may be caused by the presence of a communication channel, or because of the efficient assignment of power and other limited resources. Intelligent mechatronic systems represent a large class of smart systems that encompass computational (i.e., hardware and software) and physical components, seamlessly integrated and closely interacting to autonomously sense and manipulate the changing state of the physical system. These systems involve a high degree of complexity at numerous spatial and temporal scales and highly networked communications integrating computational and physical components. Model predictive control (MPC) is a promising paradigm for high-performance and cost-effective control of networked and distributed mechatronic systems. This talk will firstly summarize the major application requirements and challenges to innovate in designing, implementing, deploying and operating intelligent mechatronic systems. Further, the robust MPC and distributed MPC design methods will be presented. Finally, the application of MPC algorithms to a variety of autonomous intelligent mechatronic systems will be illustrated.

DT Interdisciplinary Frontiers II (IF2-2)



Jun QIAN

Research manager, Department of Mechanical Engineering, KU Leuven ;
Core lab manager, Manufacturing and Automation corelab, Flanders Make (Belgium)

Title:

Digital twin of manufacturing processes for enhanced process stability and efficiency

Abstract

Process efficiency, quality and costs are the three key elements in manufacturing. Digital twins of manufacturing processes, based on the theoretical process models and enriched with in-process measurement data of critical parameters, have demonstrated promising effects on improving the process stability, its efficiency and quality prediction. Two case studies, namely blind hole drilling by electrical discharge machining (EDM) and mechanical milling, are explained in this presentation. In the EDM drilling process, machine learning is applied to update the digital twin of the process.

DT Interdisciplinary Frontiers II (IF2-3)



Min XIA

Associate Professor and the Director,
The University of Western Ontario (Canada)

Title:

Trustworthy AI-based Solutions for Industrial Machine Condition Monitoring

Abstract

Deep neural networks have been widely investigated in data-driven machine condition monitoring due to their superior capabilities in classification and regression. However, the "black box" nature of deep learning has limited the practical application of these methods in real industrial settings. Building reliable and trustworthy approaches is both an urgent and demanding task in academia and industry. This presentation will illustrate trustworthy AI-based methods, focusing on interpretable model learning and uncertainty estimation, which can significantly enhance the reliability of AI-based solutions for industrial machine condition monitoring. Through real-world case studies, the research and future application scenarios of these methods will be explored.

DT Interdisciplinary Frontiers II (IF2-4)



Qiuhua HUANG

Associate Professor,
Colorado School of Mines (U.S.)

Title:

Convergence of AI, Physics, and Computing for Intelligent Emergency Control in Large-Scale Power Systems

Abstract

This presentation explores a cutting-edge convergence framework for intelligent emergency control in large-scale power systems, which leverages the integration of machine learning, physics, advanced computing, and grid control. Power systems are operating closer to their limits with increasing uncertainties, posing new challenges to stability and security, especially during extreme events like hurricanes and heat waves. The framework is exemplified through a deep reinforcement learning (DRL)-based approach, which has been applied to a synthetic Texas power system of over 3,000 buses and tested with more than 56,000 scenarios. The proposed hybrid system demonstrated a 26% reduction in load shedding, outperforming traditional rule-based controls in nearly 100% of cases, highlighting the effectiveness of AI for grid control. This presentation will offer attendees insights into the future of AI-driven digital twins for grid operations, with an emphasis on scalability, adaptability, and security in real-time control environments. The convergence framework presented can serve as a model for developing resilient, intelligent grid systems of the future.

DT Interdisciplinary Frontiers II (IF2-5)



Qi LIU

Lecturer,
University of Bath (UK)

Title:

Predictive digital twin-driven dynamic error control for ultra-precision machining: A Case study in slow-tool-servo ultra-precision diamond turning

Abstract

A predictive digital twin (DT)-driven dynamic error control approach is presented for accuracy control in ultra-precision machining. Taking slow-tool-servo ultra-precision diamond turning processes as a demonstrator, an explainable artificial intelligence-enabled real-time DT of the total dynamic error (inside and outside the servo loop) was established using in-line acceleration input data near the tool. A feedforward controller was used to mitigate the total dynamic errors before they came into effect. The machining trials using this approach showed that significant improvement in machining accuracy (87%, surface form accuracy; 95%, phase accuracy with precisions of 0.06 μm and 0.05°), and efficiency (8 times the state-of-the-art) were successfully achieved.

DT Interdisciplinary Frontiers II (IF2-6)



Pingchuan Ma

Postdoctor,
The Imperial College London (UK)

Title:

Deep Audio-Visual Speech Recognition

Abstract

Automatic Speech Recognition (ASR) is the task of recognizing speech by using audio information. Recent advances in deep learning have substantially improved speech recognition technology, leading to widespread commercial applications across various scenarios. However, even the most advanced ASR systems struggle with robustness in noisy environments. A solution to mitigate this issue is the incorporation of visual information alongside audio data, as the visual stream is not affected by background noise. This presentation will explore the integration of audio-visual speech recognition (AVSR). It will begin by discussing recent progress in the field of visual speech recognition, commonly referred to as lipreading. Then, it will highlight how cross-modal learning can further enhance lipreading performance. Finally, the presentation will introduce self-supervised learning methods for joint audio-visual representation and discuss potential trends for future developments.

DT Interdisciplinary Frontiers II (IF2-7)



Gangming ZHAO

PhD Candidate,
The University of Hong Kong (China)

Title:

Diagnose Like a Radiologist: Hybrid Neuro-Probabilistic Reasoning for Attribute-Based Medical Image Diagnosis

Abstract

Effectively modeling attributes as well as all relationships involving attributes could boost the generalization ability and verifiability of medical image diagnosis algorithms. In this topic, we introduce a hybrid neuro-probabilistic reasoning algorithm for verifiable attribute-based medical image diagnosis. There are two parallel branches in our hybrid algorithm, a Bayesian network branch performing probabilistic causal relationship reasoning and a graph convolutional network branch performing more generic relational modeling and reasoning using a feature representation. Tight coupling between these two branches is achieved via a cross-network attention mechanism and the fusion of their classification results. We have successfully applied our hybrid reasoning algorithm to two challenging medical image diagnosis tasks. On the LIDC-IDRI benchmark dataset for benign-malignant classification of pulmonary nodules in CT images, our method achieves a new state-of-the-art accuracy of 95.36% and an AUC of 96.54%. Our method also achieves a 3.24% accuracy improvement on an in-house chest X-ray image dataset for tuberculosis diagnosis.

DT Interdisciplinary Frontiers II (IF2-8)



Yulong ZHAO

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

Title:

Ensemble Learning-Based Stability Improvement Method for Feature Selection towards Performance Prediction

Abstract

The uncertainty and complexity of real data collected in the industrial production process increase the difficulty in data-based knowledge discovering. Feature selection is an important step to remove redundant and irrelevant data, and thus it is essential to construct an efficient feature selection method. In this paper, an ensemble learning-driven stable feature selection method is proposed to improve the stability and accuracy of the feature selection. Firstly, datasets of different characteristics are generated to increase the diversity of data segments for feature selection. Secondly, two criteria (stability and prediction accuracy) are adopted to evaluate the performance weight of each feature selection algorithm, to ensure that the results of high-performance selectors have high priority in the algorithm aggregation process. Thirdly, the feature subsets are weighted and filtered based on expert experience to further ensure its stability. Finally, comparative experiments are conducted to show the effectiveness of the proposed method.

Digital Twin Diverse Industrial Applications (DIA)

Chair



Li YI

Associate Professor (Dr.-Ing.)

Beihang University (China)

Co-Chair



Matthias KLAR

Senior Research Fellow (Dr.-Ing.),

University of Kaiserslautern-Landau (Germany)

Session on

Digital Twin Diverse Industrial Applications (DIA)

Wednesday, October 16th 2024

Tencent ID: 735-800-340
https://meeting.tencent.com/dm/LIs2UjBb03GO

Milan Time	Beijing Time	Agenda
15:00	21:00	**DIA-1** Enhancing Worker Health and Safety in Construction Through Motion Capture Systems: Insights from Industry 5.0 Md Hadisur RAHMAN
15:30	21:30	**DIA-2** Digital Twins as Key Technology in Sustainable Manufacturing, Robotics and Space Applications Benjamin SCHLEICH
16:00	22:00	**DIA-3** Industrial AI-enabled Smart Manufacturing: Methods and Applications Dazhong WU
16:30	22:30	**DIA-4** Leveraging Large Language Models for Humanoid Cognition in Proactive Human-Robot Collaboration Shufei LI
17:00	23:00	**DIA-5** Changeable production systems for circular manufacturing by utilizing digital twins Merlin KORTH
17:30	23:30	**DIA-6** Unlocking the Potentials of a Service-Oriented Architecture in Production Planning and Control Sebastian BEHRENDT

DT Diverse Industrial Applications (DIA-1)



Md Hadisur Rahman

Graduate Research Assistant (M.S.),
West Virginia University (US)

Title:

Enhancing Worker Health and Safety in Construction Through Motion Capture Systems: Insights from Industry 5.0

Abstract

Industry 5.0 emphasizes the collaboration between humans and intelligent systems, driving technological advancements across various sectors. In this context, Motion Capture (MoCap) technology plays a crucial role in enhancing worker health and safety in the construction industry by seamlessly integrating with these intelligent systems. The study analyzed 52 studies from the Scopus database, demonstrating the effectiveness of MoCap technology in reducing work-related musculoskeletal disorders and occupational hazards. The research revealed that marker less systems and wearable IMU sensors are widely used in construction. Finally, the study contributes to the body of knowledge on how MoCap technology ensures construction safety and offers suggestions for future research directions in line with Industry 5.0 principles.

DT Diverse Industrial Applications (DIA-2)



Benjamin Schleich

Professor (Dr.-Ing.),
Technical University of Darmstadt (Germany)

Title:

Digital Twins as Key Technology in Sustainable Manufacturing, Robotics and Space Applications

Abstract

The digital twin as a virtual representation of physical assets offers immense potentials for new business models and product-service-systems. Considering these benefits, the presentation will dive into the technological fundamentals of digital twins and will highlight state-of-the-art applications of digital twins in sustainable manufacturing, robotics, and space technology. Specifically, it will be shown how sustainability data models support the design of digital twins for CO2-efficient manufacturing and how digital process twins may support the realization of in-orbit small satellite factories. Beside this, future research directions are carved out.

DT Diverse Industrial Applications (DIA-3)



Dazhong Wu

Associate Professor (PhD),
University of Central Florida（US）

Title:

Industrial AI-enabled Smart Manufacturing: Methods and Applications

Abstract

Despite the broad range of applications for artificial intelligence (AI) in tasks such as image recognition and natural language processing, there are still challenges to implementing AI in the manufacturing industry. One of the main obstacles is the difficulty in integrating prior knowledge into machine learning to provide explanations for the decisions made by AI systems, as well as the challenge of ensuring that AI models can be generalized to different manufacturing settings. This presentation will explore the use of deep learning, physics-informed machine learning, and transfer learning in the context of manufacturing and the mechanics of additively manufactured materials. Specifically, it will showcase a deep learning model that predicts the temperature of the melt pool during a directed energy deposition process, a physics-informed machine learning model that incorporates the physics of the chemical mechanical planarization process, and a novel transfer learning framework that can predict the complex mechanical behavior of additively manufactured composites and lattice structures.

DT Diverse Industrial Applications (DIA-4)



Shufei Li

Postdoctoral Research Fellow (PhD),
Nanyang Technological University (Singapore)

Title:

Leveraging Large Language Models for Humanoid Cognition in Proactive Human-Robot Collaboration

Abstract

Proactive Human-Robot Collaboration (HRC) aims for mutual-cognitive, predictable, and self-organizing teamwork between humans and robots, vital for human-centric smart manufacturing. To enable Proactive HRC, methods such as deep neural networks for visual detection, scene graphs for decision-making, and reinforcement learning for robot execution have been explored. However, these methods often need re-training with domain-specific datasets, limiting their generalizability. Large Language Model (LLM) technology offers a solution for understanding tasks, modeling human intentions, and planning robot actions using vision-language instructions. This paper explores humanoid cognition in Proactive HRC, evaluating LLM methods for task explainability, human-centricity, and robot executability, and discusses future integration prospects in manufacturing.

DT Diverse Industrial Applications (DIA-5)



Merlin Korth

Research Associate,
Karlsruhe Institute of Technology (Germany)

Title:

Changeable production systems for circular manufacturing by utilizing digital twins

Abstract

High Volume manufacturing is characterized by the need to control a stable manufacturing system, often in form of a semi-automated system, and, thus, provides an ideal testbed for the implementation of digital twins in a brownfield environment. The proposed approach aligns a manual crafted digital twin event discrete simulation over a long term with the real system behavior. Therefore, both automated stations, their respective behavior as well as humans in the manufacturing system are considered. The validation in a large real-world system shows the ability to control deviation between the digital twin and reality in an acceptably narrow band.

DT Diverse Industrial Applications (DIA-6)



Sebastian Behrendt

Research Associate,
Karlsruhe Institute of Technology (Germany)

Title:

Unlocking the Potentials of a Service-Oriented Architecture in Production Planning and Control

Abstract

The trends of shorter product lifecycles and volatile market environments require manufacturers to operate their productions efficiently to maintain their competitiveness and customer satisfaction. Industrie4.0 opened up the potential to use data of a digitized production system to analyze it, understand it and improve it with suitable mining and optimization algorithms. Although such algorithms exist, their application is often limited in practice because their use is mostly manual and requires expertise. This keynote shows how to resolve this limitation and make production planning and control (PPC) more automated and integrated by utilizing service-oriented architecture.

Digital Twin Ocean Engineering & Equipment Ⅰ（OE1）

Chair



Honggen ZHOU

Professor,

Jiangsu University of Science and Technology (China)

Co-Chair



Jinfeng LIU

Associate professor,

Jiangsu University of Science and Technology (China)



Vsevolod V. KORYANOV

Associate Professor,

Moscow State Bauman Technical University (Russia)



Xuwen JING

Professor,

Jiangsu University of Science and Technology (China)

Session on

Digital Twin Ocean Engineering & Equipment Ⅰ (OE 1)

Tuesday, October 15th 2024

Tencent ID: 348-408-610
https://meeting.tencent.com/dm/H3jXBDW2PVMu

Milan Time	Beijing Time	Agenda
14:00	20:00	**OE1-1** Research on Digital Twin of Self elevating Platform Bo ZHOU
14:30	20:30	**OE1-2** Digital Twin Model-driven Adaptive Welding of Curved Ship Blocks Cheng LUO
15:00	21:00	**OE1-3** Forming Difficulty Evaluation of Line Heating for Complex Curved Ship Plate Shun WANG
15:30	21:30	**OE1-4** Optimal Design of Fixture Layout for Compliant Part with Application in Ship Hull Assembly Process Changhui LIU
16:00	22:00	**OE1-5** Digital Twins for Modeling Flight Environment Processes in Aerospace Spacecraft Design Vsevolod V. KORYANOV
16:30	22:30	**OE1-6** Deep Reinforcement Learning for Optimizing fleet Management in Shipbuilding: A Comparative Study Xiaolei XIANG
17:00	23:00	**OE1-7** Modeling the laser welding during ship building Lu WANG
17:30	23:30	**OE1-8** Deep Learning Analysis of Spray Particles Characteristics for Gas Turbine Engine Wenjing XING

DT Ocean Engineering & Equipment Ⅰ（OE1-1)



Bo ZHOU

Professor,
Dalian University of Technology (China)

Title:

Research on Digital Twin of Self elevating Platform

Abstract

On the basis of the initial equipment of the offshore self elevating platform, this study adds a series of sensor systems to monitor structural data and ensure the information transmission and reception functions of key monitoring equipment. Based on the completion of the monitoring system, develop a software system database and 3D display module, establish a comprehensive data acquisition and simulation calculation plan, build a digital 3D display platform for the platform structure, and realize the digital twin and intelligent application of the self elevating platform.

DT Ocean Engineering & Equipment Ⅰ（OE1-2)



Cheng LUO

Associate Professor,
Shanghai Jiao Tong University (China)

Title:

Digital Twin Model-driven Adaptive Welding of Curved Ship Blocks

Abstract

Welding path planning is vital to improve the efficiency of the robot system in welding of curved ship blocks. Common welding path planning methods is mainly depending on discrete points fitting to determine the curved seam positions in physical welding conditions, leading in both decreases of efficiency and accuracy. In this report, a deep-learning empowered-digital twin system was proposed to plan and adjust welding paths by modeling the seams positions and features during welding process. The model successfully facilitated the adaptive control of weld positions for curved seams in real time, resulting in the improvement of welding quality.

DT Ocean Engineering & Equipment Ⅰ（OE1-3)



Shun WANG

Associate Professor,
Dalian Maritime University (China)

Title:

Forming Difficulty Evaluation of Line Heating for Complex Curved Ship Plate

Abstract

To solve the problem that the lack of reference for hull plate division leads to the difficulty and low efficiency of curved plate forming, the forming difficulty evaluation of complex curved hull plate is researched. Considering the characteristics in curved plate forming process, the weight coefficient of different affecting factors on the forming difficulty of curved plate is quantified. The forming difficulty of curved hull plate is calculated. By comparing and analyzing the forming evaluation results and forming time data of curved hull plate, the rationality of the evaluation method is verified. The research can provide reference for the reasonable division of hull plate.

DT Ocean Engineering & Equipment Ⅰ（OE1-4)



Changhui LIU

Associate Professor,
Tongji University (China)

Title:

Optimal Design of Fixture Layout for Compliant Part with Application in Ship Hull Assembly Process

Abstract

In the ship assembly process, a large number of compliant parts are involved. The ratio of the part thickness to the length or the width is very small. Fixture design is a critical task in the ship assembly process due to its impact on the deformation and dimensional variation of the compliant parts. The current practice in the ship industry, the fixtures are uniformly distributed, which is non-optimal and large deformation will occur. This speech will talk about a series of studies of Prof. Liu for optimal design of fixture layout in the ship assembly process by integrating direct stiffness method and Metaheuristic algorithm, which significantly reduced the deformation of the compliant part in the ship assembly process

DT Ocean Engineering & Equipment Ⅰ（OE1-5)



Vsevolod V. KORYANOV

Associate professor,

Moscow State Bauman Technical University (Russia)

Title:

Digital Twins for Modeling Flight Environment Processes in Aerospace Spacecraft Design

Abstract

Currently, the aerospace industry is developing in almost all areas: these include near-Earth constellations of spacecraft, and the development of deep space exploration. Designing spacecraft that move in deep space is impossible without the use of digital twins. The process is complicated by the fact that it is often very difficult and expensive or impossible to create full-fledged experimental setups that simulate the process of spacecraft movement in space. The processes that occur when spacecraft move in space are sometimes very fleeting and important. In the direction of designing spacecraft, the use of digital twins is very relevant and necessary.

DT Ocean Engineering & Equipment Ⅰ（OE1-6)



Xiaolei XIANG

Associate professor,
Curtin University WASM (Australia)

Title:

Deep Reinforcement Learning for Optimizing fleet Management in Shipbuilding: A Comparative Study

Abstract

This research investigates the application of Deep Reinforcement learning (DRL) algorithms to optimize fleet management in shipbuilding operations. Three DRL models-modified Actor-Critic (AC), Prioritized Experience Replay (PER) Dueling Double Q-network (DDQN), and Proximal Policy Optimization (PPO)-are developed and accessed for their effectiveness in improving efficiency and productivity. The study compares their DRL approaches to traditional methodologies, demonstrating superior performance in enhancing operational efficiency. The findings provide valuable insights into the potential of DRL algorithms to drive intelligent fleet management and resource optimization in the shipbuilding industry.

DT Ocean Engineering & Equipment Ⅰ（OE1-7)



Lu WANG

Assistant Professor,
City University of Hong Kong (China)

Title:

Modeling the laser welding during ship building

Abstract

Metal melting and solidification is the basic process in both laser powder bed fusion and laser welding during ship building and repairing. However, the quality of the fabrication is difficult to be controlled though trail-and-error experiments due to the laser influencing factors. The high cost of experimental measurements also poses difficulties for the processing parameter optimization. To solve this tough situation, high-fidelity simulation is an effective approach to explore the mechanisms behind it and reduce the defects formation. In this report, a multi-physics thermal-fluid model, incorporating heat transfer, metal evaporation, Marangoni effect, etc., is brought up to simulate the pore formation. To optimize the process, an external magnetic field is applied to generate high intensity Lorentz force to modify the molten pool flow and adjust the grain morphology. These simulation results have been validated with advanced experiment measurements, which lays a solid foundation for further study to optimize the welding process.

DT Ocean Engineering & Equipment Ⅰ（OE1-8)



Wenjing XING

Assistant Professor,
Yamagata University (Japan)

Title:

Deep Learning Analysis of Spray Particles Characteristics for Gas Turbine Engine

Abstract

This study aims to comprehensively investigate the atomization process and characterize the spray, encompassing both ligaments and droplets, through the application of deep learning techniques. The spray, injected from a twin-fluid atomizer into a crossflow, is analyzed using a hybrid approach involving CNN-based deep-learning and image processing to detect spray particles as regions of interest (ROI). Post-analysis of the obtained ROIs involves assessing displacement, sizes, and posture (orientation) distribution of spray particles. Additionally, a novel definition is proposed to determine the average velocity vectors of spray particles. The results reveal a noticeable change in the flying direction, transitioning from predominantly horizontal angles to nearly vertical angles, especially evident with an increasing atomizing air flow rate.

Digital Twin Ocean Engineering & Equipment II （OE2）

Chair



Yanjun LIU

Professor,

Shandong University (China)

Co-Chair



Elena De MOMI

Professor,

Politecnico di Milano (Italy)



Hongda SHI

Professor,

Ocean University of China (China)

Session on

Digital Twin Ocean Engineering & Equipment II (OE 2)

Wednesday, October 16th 2024

Tencent ID: 770-109-243
https://meeting.tencent.com/dm/LpQ97tYd4QWb

Milan Time	Beijing Time	Agenda
10:00	16:00	**OE2-1** Hydrodynamic analysis of multi-purpose coastal and offshore structures Jing GENG
10:30	16:30	**OE2-2** The Establishment and Application of Digital Twin Model for Oscillating Water Column Wave Energy Converter Zhen LIU
11:00	17:00	**OE2-3** Digital twin technology for passive warming systems in coastal wetlands Application in the field of coastal wetland research Lei GUO
11:30	17:30	**OE2-4** Virtual-real fusion based design of floating platform of offshore wind turbine Hongwei LIU
12:00	18:00	**OE2-5** OWC wave energy converter array coupled with a parabolic-wall energy concentrator Dezhi NING
15:00	21:00	**OE2-6** Experimental investigation of a Wind-Tidal Combined Power Generation Device Yong MA
15:30	21:30	**OE2-7** Experimental and numerical study of an evolutionary algorithm-based optimization approach for multi-mode wave energy converters Dahai ZHANG
16:00	22:00	**OE2-8** Development of oscillating body wave energy converter and relevant hybrid systems Binzhen ZHOU
16:30	22:30	**OE2-9** Research on Wave Energy Supply of Underwater Vehicle with Hydrofoils Gang XUE
17:00	23:00	**OE2-10** Influence of the hydraulic power take-off system on the dynamic response and power output of a wind-wave hybrid system Tiesheng LIU

DT Ocean Engineering & Equipment II (OE2-1)



Jing GENG

Professor,
Harbin Engineering University (China)

Title:

Hydrodynamic analysis of multi-purpose coastal and offshore structures

Abstract

Multi-functional coastal and offshore marine engineering structures, designed to fulfill multiple purposes such as offshore renewable energy utilization, aquaculture, and breakwater functionality, have emerged in recent years. This presentation provides a summary of our recent research in this field, encompassing hydrodynamic modeling, analysis, and design criteria. Specifically, we will present the hydrodynamic modeling of wave interaction with periodic structures and multi-body systems with complex connections. Motivated by two prototypes that have undergone sea trials in China, we offer a comprehensive analysis of the hydrodynamic behavior of these hybrid systems. Our newly proposed methodology and illustrated mechanisms have the potential to serve as a scientific foundation for the design of such hybrid systems.

DT Ocean Engineering & Equipment II (OE2-2)



Zhen LIU

Professor,
Ocean University of China (China)

Title:

The Establishment and Application of Digital Twin Model for Oscillating Water Column Wave Energy Converter

Abstract

Accurately predicting the energy output of a wave energy device is important for evaluating its LCoE and facilitating commercial development. In this study, a digital twin model for the OWC device was firstly established to include both the air chamber and the turbine and associated stages. The capability of the model was comprehensively verified and validated by relevant experimental studies, and the operating performance of a prototype plant was also investigated using this digital twin model.

DT Ocean Engineering & Equipment II (OE2-3)



Lei GUO

Associate Professor,
Shandong University (China)

Title:

Digital twin technology for passive warming systems in coastal wetlands Application in the field of coastal wetland research

Abstract

The team has developed a passive warming system for coastal wetlands, setting up a passive open-top air chamber warming device to simulate future global warming scenarios, forming a global observation network for coastal wetlands, and investigating the changes in ecosystem plant communities, microbial composition, carbon and nitrogen cycling, and other biogeochemical processes under the conditions of warming experiments to predict the ecosystem's response to global warming. The system applies digital twin technology, adopts IoT communication technology to realize multi-circle element monitoring, is based on online evaluation tools to realize dynamic evaluation of health status, and establishes an AI model to support rapid estimation of regional carbon fluxes to serve wetland research. Under the deployment of the Global Observation Network of Coastal Wetlands, the team carried out an operational survey of coastal wetlands in Yancheng, Jiangsu Province, and formed rich data resources, which were uploaded to the digital system of “GeoCloud”, so that relevant people can easily query them.

DT Ocean Engineering & Equipment II (OE2-4)



Hongwei LIU

Professor,
Zhejiang University (China)

Title:

Virtual-real fusion based design of floating platform of offshore wind turbine

Abstract

Floating offshore wind turbine is a promising filed for renewable energy development. The cost of flaoting platform is main obstacle for its large scale commercial deployment,. Aiming at the lowering the cost of platform, a virtual-real fusion based floating platform design method is put forword, which integrates the onsite load measurement and numerical model and generates a rational platform geometry parameters and mechanical strength, at the same time to keep the hydrodymic stability in real sea environments. The genetic algorithm and ant colony algorithm were used to realize it. The paper is arranged as follows, the first part gives the optimized design method of floating platform, followed by the simulation of hydrodynamic performance The results showed the structure of floating platform is satisfied in the aspect of structure strengh, hydrodynamic stablity and construction cost .

DT Ocean Engineering & Equipment II (OE2-5)



Dezhi NING

Professor,
Dalian University of Technology (China)

Title:

OWC wave energy converter array coupled with a parabolic-wall energy concentrator

Abstract

A heuristic method to identify the optimal siting of the component, cylindrical OWC WECs in the array, installed in the concave opening of the wall is presented. The most advantageous location of the chambers is found to lie on a parabolic curvature line which is inset from the wall. The hydrodynamic power and efficiency of each chamber in each of the arrays is determined, and subsequently the aggregated array performance is established. It is found that the primary OWC chamber in the array configuration can attain approximately the same hydrodynamic power output as a single, isolated OWC chamber located the parabolic wall focus, albeit with a narrower energy capture bandwidth. The secondary and tertiary component chambers in the arrays contribute a lesser, yet still considerable quantity of hydrodynamic power to the consolidated system. The cumulative hydrodynamic efficiency of the collective arrays is less than the hydrodynamic efficiency of a single OWC chamber at the wall focus, but more efficient than an isolated OWC chamber positioned in open-sea conditions. Moreover, the hydrodynamic efficiency of the arrays exhibits better stability across the range of incident wave periods investigated, denoting that the individual component chambers in the array are efficacious at different incident wave conditions

DT Ocean Engineering & Equipment II (OE2-6)



Yong MA

Professor,
Sun Yat-sen University (China)

Title:

Experimental investigation of a Wind-Tidal Combined Power Generation Device

Abstract

The development and utilization prospects for wind energy and tidal energy are vast; however, current devices for harnessing these energies are typically designed for single energy sources, leading to high costs, poor stability, and limited output. This paper proposes a novel semi-submersible wind-tide hybrid power generation device aimed at integrating the use of both wind and tidal energies. Experimental studies have been conducted to evaluate its performance. To address the issue of reduced hydrodynamic performance due to scale effects on the turbine and rotor, the blade surfaces were treated with roughness. Additionally, an equivalent loading system for a vertical-axis dual-rotor turbine was developed, overcoming limitations imposed by the experimental tank conditions. A comprehensive model test method and measurement platform for the semi-submersible wind-tide hybrid power generation device, considering the combined effects of wind, waves, and currents, were established. The findings of this study can serve as a valuable reference for the development of similar devices.

DT Ocean Engineering & Equipment II (OE2-7)



Dahai ZHANG

Professor,
Zhejiang University (China)

Title:

Experimental and numerical study of an evolutionary algorithm-based optimization approach for multi-mode wave energy converters

Abstract

First of all, a brief summary concerning current status on wave energy converter optimization will be given. Then the evolutionary algorithm-based optimization approach will be introduced, including the contents of optimization procedure, algorithms setup and the geometry definition. After that, the concluding remarks will be presented.

DT Ocean Engineering & Equipment II (OE2-8)



Binzhen ZHOU

Professor,
South China University of Technology (China)

Title:

Development of oscillating body wave energy converter and relevant hybrid systems

Abstract

Wave energy has recently become a research highlight of ocean renewable energy due to its several merits such as the vast reserves. Till now, more than a thousand wave energy converters (WECs) based on various energy conversion mechanisms have been proposed, but few of these were commercially used. As an emerging marine renewable energy, the present development stage of wave energy is hindered by high costs. Despite the mentioned premature features, wave energy also has an irreplaceable role in niche applications of powering deep-sea reefs, offshore platforms, aqua cages, and research buoys. Therefore, local supply and consumption of wave energy has become an important trend and cutting-edge topic. The report focuses on the oscillating body WECs, which are more adaptive to offshore environments, more efficient, and more flexible in construction and deployment. These oscillating body WECs are also combined with other offshore equipment to form innovative hybrid systems which exploiting the advantages of shared infrastructures and maintenance, helping reduce the cost and provide a promising application prospect. This report introduces two typical hybrid systems, including an oscillating body WEC-breakwater hybrid system and an oscillating body WEC-floating offshore wind turbine hybrid system. The hydrodynamic couplings in the multi-body systems and their influence on the dynamic and power performance of the hybrid systems are emphasized .

DT Ocean Engineering & Equipment II (OE2-9)



Gang XUE

Associate Researcher,
Shandong University (China)

Title:

Research on Wave Energy Supply of Underwater Vehicle with Hydrofoils

Abstract

In order to solve the current problem of renewable energy capture and motion synergy faced by underwater vehicle, a new underwater vehicle with hydrofoils is proposed, which is capable of capturing wave energy and controlling the vehicle. Firstly, a structural design of the underwater vehicle is carried out, in which four hydrofoils are circumferentially distributed in the vehicle shell, and a buoyancy adjustment device is installed in the submerged part of each hydrofoil. Secondly, a hydraulic transmission system for the underwater vehicle is designed, which can realize the conversion and storage of wave energy, drive the movement of hydrofoils and regulate the drainage volume of the vehicle. Finally, a multi-mode motion strategy for the vehicle is constructed, which can use hydrofoil motion and buoyancy drive to cooperate with each other to realize the vehicle's underwater hovering, surfacing and diving, gliding motion, trajectory tracking, and accurate bottoming, and can also use hydrofoils to capture wave energy from the surface of the sea to continuously provide energy supply. In addition, using digital twin technology, we can create exact virtual copies of the vehicle in a digital environment that can be used to simulate and optimize its performance in different sea states. Therefore, the underwater vehicle with hydrofoils can extend the effective working time and improve the precision operation capability, which provides a new solution to the problem of energy supply and underwater movement..

DT Ocean Engineering & Equipment II (OE2-10)



Tiesheng LIU

Ph.D student,
Shandong University (China)

Title:

Influence of the hydraulic power take-off system on the dynamic response and power output of a wind-wave hybrid system

Abstract

The power take-off (PTO) system plays a crucial role in the wind-wave hybrid system that directly affects the efficiency of wave energy conversion and the relative motion between buoys and the platform. The hydraulic PTO system, a commonly used type of wave energy conversion, has demonstrated practicality and reliability in practical projects. Effects of the hydraulic PTO system on the dynamic response and power output of the hybrid system are unclear due to the limitations of current simulation tools. Therefore, this study proposes an aero-hydro-servo-hydraulic-mooring fully coupled simulation method to investigate the effects of hydraulic parameters on the hybrid system. The results show that the hydraulic parameters have a significant effect on the heave and pitch natural periods, while they have a negligible effect on the surge natural period. The hydraulic parameters affect the surge, heave, and pitch motion responses of the platform, and the results depend on the phase and amplitude of the reaction forces of the hydraulic PTO system at different locations in the wave energy converters (WECs) micro array. For deterministic sea states, the same set of hydraulic parameters cannot simultaneously maximize the power generation of the WEC micro array and minimize the pitch motion response of the platform. Hydraulic parameters have negligible effect on the average values of the power generation and rotor torque of the wind turbine, but affect the amplitudes. Furthermore, the established framework can effectively simulate the working process of the hydraulic PTO system in a wind-wave hybrid system, which can provide essential pre-research for the actual hydraulic control to improve the wave energy conversion efficiency and hybrid system stability.

Digital Twin Network（N）

Chair



Tao SUN

Chief Expert of China Mobile

China Mobile Research Institute (China)

Co-Chair



Diego LOPEZ

Senior expert

Telefonica I+D, Spain (Spain)



Stephen TERRILL

Senior expert

Ericsson, Swed (Australia)

Session on

Digital Twin Network (N)

Wednesday, October 16th 2024

Tencent ID: 657-553-963
https://meeting.tencent.com/dm/6pINw8xe7S9K

Milan Time	Beijing Time	Agenda
10:00	16:00	**N-1** The Role of Network Digital Twins in Achieving Autonomous Networks Jörg NIEMÖLLER
10:30	16:30	**N-2** Digital Twin of Digital Networks Chen TIAN
11:00	17:00	**N-3** Telefónica’ s Approaches to NDT descriptors Jose Manuel MANJON
11:30	17:30	**N-4** Open Source for NDT infrastructures Mario Sanz RODRIGO
12:00	18:00	**N-5** Exploring and Building Digital Twins for Quantum Key Distribution Networks Blanca LOPEZ
12:30	18:30	**N-6** Exploration of key technologies and standardization of network digital twin Cheng ZHOU

Digital Twin Network（N-1）



Jörg NIEMÖLLER

Expert of Analytics and Customer Experience,
Ericsson (Sweden)

Title:

The Role of Network Digital Twins in Achieving Autonomous Networks

Abstract

A network digital twin is a digital representation of a real-world object synchronized at a specified periodicity and fidelity, and is a powerful concept which can be applied to telecommunication networks in many ways. One such application is in supporting the common challenge that the telecommunication community is pursuing – that of achieving an autonomous network. The Telecom Management Forum (TMF) has being progressing the evolution of a number of concepts in the support of an autonomous network. An autonomous network has to work through a number of scenarios in order to decide on the best course of action, where a digital twin can be of a great support. This presentation will explore how a digital twin can support in achieving an autonomous network in telecommunications.

Digital Twin Network（N-2)



Chen TIAN

Professor,
Nanjing University (China)

Title:

Digital Twin of Digital Networks

Abstract

The digital twin of a network digitally reproduces the physical network by collecting data from the physical network, including data packets, configuration information, node status, etc., in real-time or non-real-time manners and storing it in a data warehouse. This supports the use of artificial intelligence, expert experience, big data analysis, and other technologies to analyze, diagnose, simulate, and make decisions for the entire lifecycle of the physical network. This report will present the preliminary progress made by the NASA research group at Nanjing University in the area of digital twins for networks.

Digital Twin Network（N-3)



Jose Manuel MANJON

Telefónica ID (Spain)

Title:

Telefónica’ s Approaches to NDT descriptors

Abstract

Network Digital Twin (NDT) as a technology for real network emulation requires frequent updates to their topologies. Telefónica proposes not only the use of data models to describe and change those topologies, but also additional formats compatible with Intent-Based interfaces so the NDT can run specific experiments and provide feedback helping to take decisions on the real network.

Digital Twin Network （N-4)



Mario Sanz RODRIGO

Professor,
Universidad Politécnica de Madrid (Spain)

Title:

Open Source for NDT infrastructures

Abstract

The concept of the digital twin of a network is based on the digital representation of real network elements or environments and enables the exchange and feedback of data between the twins. In recent years, the application of this concept in areas such as cyber security, intelligent management or network optimization has aroused the interest of science and industry. This presentation explores the challenges associated with the implementation of NDT environments and proposes a set of platforms and technologies that enable the creation of these virtual environments where DTs can be hosted

Digital Twin Network（N-5）



Blanca LOPEZ

PhD Candidate,
Universidad Carlos III de Madrid (Spain)

Title:

Exploring and Building Digital Twins for Quantum Key Distribution Networks

Abstract

Quantum Key Distribution (QKD) networks, which use the principles of Quantum Mechanics to securely distribute cryptographic keys to remote entities, stand out as one of the most attractive and significant applications of quantum communication technologies. Still, quantum devices and equipment are in a developmental stage, making their availability low and their price high, and hindering the settlement of these new technologies. In this talk, we explore the benefits of using digital twin technology to advance QKD network research. We introduce Quditto, a software solution designed to deploy and configure emulated QKD networks, enabling researchers to conduct experiments and simulations without requiring physical quantum equipment or risking the integrity of existing QKD networks. Quditto is a first major step towards the creation of a quantum digital twin, that will enable hybrid deployments and communication in real-time with the physical infrastructure, a line we are currently working on.

Digital Twin Network（N-6)



Cheng ZHOU

Project Manager,
China Mobile Research Institute (China)

Title:

Exploration of key technologies and standardization of network digital twin

Abstract

Network digital twin has become a research hotspot in academia and industry. With the development of technology, the key technology and application value of network digital twin are gradually recognized and agreed. This report discusses the core technologies of network digital twin, including real-time data acquisition and processing, modeling of complex network environment, and network verification. And the report also analyzes the current standardization progress and challenges in the field of network digital twin, and puts forward some possible standardization paths and suggestions to promote the wide application of network digital twin technology in various network domains.

DT Electric, Control and Energy Systems (ES)

Chair



Li WANG

Professor

Nanjing University of Aeronautics and Astronautics (China)

Co-Chair



Qunfang WU

Associate Research Fellow

Nanjing University of Aeronautics and Astronautics (China)



Kangkang ZHANG

Research Associate

Imperial College London (UK)

Session on

Digital Twin Electric, Control and Energy Systems (ES)

Wednesday, October 16th 2024

Tencent ID: 321-839-619
https://meeting.tencent.com/dm/oApyNPUreaCq

Milan Time	Beijing Time	Agenda
10:00	16:00	**ES-1** Digital Design and Digital Service for Power Electronics Applications Huai WANG
10:30	16:30	**ES-2** Digital Twins: Unveiling the Challenges and Forecasting the Future Trends Hui-Hwang GOH
11:00	17:00	**ES-3** Smart Multi-vector Integrated Energy System via Digital Twin Minglei YOU
11:30	17:30	**ES-4** Optimal Sizing and Energy Management of Energy Storage Systems for Microgrid Applications Qian XUN
12:00	18:00	**ES-5** Oceano’ s-DT: A Digital Twin Platform for Water Distribution Networks Stelios VRACHIMIS

DT Electric, Control and Energy Systems (ES-1)



Huai WANG

Professor,
Aalborg University (Denmark)

Title:

Digital Design and Digital Service for Power Electronics Applications

Abstract

Power electronic converters are applied in numerous modern energy systems, such as wind turbines, Photovoltaics (PV), Power-to-X, electric vehicles, data centers, mobile phones, and smart homes. In contrast to CPUs/GPUs that process digitalized information, power electronic converters process electrical energy by efficiently converting voltage, current, or frequency. They are ubiquitous in electricity generation, transmission, distribution, and consumption, forming a critical part of the infrastructure for the green transition. Digital techniques, such as Digital Twin (DT) concept, provide new opportunities in the design, control, and operation optimization of energy materials, components, assemblies, and systems. Nevertheless, the effective implementation of DT for energy applications relies on an in-depth understanding of engineering problems and their modeling in deterministic/stochastic environments, data collection/analytics methods, and affordable algorithms and hardware implementations. This talk will focus on a few examples of DT application in the design phase (i.e., digital design) and operation phase (i.e., digital service) of power electronic converters.

DT Electric, Control and Energy Systems (ES-2)



Hui-Hwang GOH

Professor, PhD, IET Fellow,
Guangxi University (China)aity (China)

Title:

Digital Twins: Unveiling the Challenges and Forecasting the Future Trends

Abstract

Digital twin technology has become an essential tool in various sectors by providing virtual replicas of real objects. This technology has been employed to improve decision-making, simulation, and predictive maintenance. Although the technology is gaining popularity, it will still encounter certain obstacles that may hinder its ability to achieve its maximum capabilities. The objective of this talk is to examine the intricate difficulties associated with the technology of digital twins. These challenges encompass issues related to data integration and security. Furthermore, the upcoming trends will be examined that are already influencing the development of digital twins. These trends encompass advancements in artificial intelligence (AI), the Internet of Things (IoT), and real-time analytics. Through the examination of these factors, our objective is to offer a thorough comprehension of the present state of digital twin technology and to forecast its future path.

DT Electric, Control and Energy Systems (ES-3)



Minglei YOU

Assistant Professor, PhD, PGCAP, FHEA, Royal Society Short Industry Fellow, University of Nottingham (UK)

Title:

Smart Multi-vector Integrated Energy System via Digital Twin

Abstract

Energy systems are critical part in achieve the global goal of carbon reduction -this talk will present a vision of the future digital twinning integrated energy system together with its key enabling technologies including Digital Twin, Internet of Things, Artificial Intelligence and the Fifth Generation (5G) cellular networks, as well as the synergy between them. Practical testbeds will be also introduced as examples to illustrate such system structure and the potential benefits.

DT Electric, Control and Energy Systems (ES-4)



Qian XUN

Senior Researcher,
RISE Research Institutes of Sweden (Sweden)

Title:

Optimal Sizing and Energy Management of Energy Storage Systems for Microgrid Applications

Abstract

Toward green energy transition, the penetration of renewable energy resources is increasingly implemented. Due to inherent natural characteristics of renewable energy resources, energy storage systems, such as battery or hydrogen technology (fuel cell, electrolyzer, and hydrogen tank), are essential to realize the efficient operation, balance the generation and consumption, and improve the availability of the power supply in microgrids. In this regard, this talk presents power architectures to integrate renewable energy resources and energy storage systems in microgrids for data center and residential community applications. An optimization framework is formulated to determine the optimal sizing and energy management. Due to the high efficiency of the battery, it is preferred to serve as the short-term energy buffer, while the high energy density of the hydrogen technology, it is preferred to serve as seasonal energy buffer to achieve the self-sufficiency.

DT Electric, Control and Energy Systems (ES-5)



Stelios VRACHIMIS

Research Associate,

KIOS Research and Innovation Center of Excellence, University of Cyprus (Cyprus)

Title:

Oceano’ s-DT: A Digital Twin Platform for Water Distribution Networks

Abstract

Digital twin technology is revolutionizing the management of water distribution networks by providing real-time insights into system behavior, enabling early detection of faults (such as leakages and equipment failure), optimizing operations, and enhancing decision-making. OceanosDT is a platform that leverages open-source software such as QGIS and the EPANET-Python Toolkit (EPyT) to create precise digital twins of water networks. By integrating real-time GIS and sensor data, OceanosDT generates accurate hydraulic and water quality models, which are continuously calibrated with sensor measurements. These digital twins are stored in a dedicated database, facilitating risk assessment, contamination management, and strategic planning for system expansion. OceanosDT represents a significant step forward in efficient and resilient water management, offering robust tools for early fault detection, operational optimization, and data-driven decision support.

Digital Twin Design (D)

Chair



Ang Liu

Associate Professor
University of New South Wales (Austrlia)

Dr. Ang Liu is an Associate Professor of Engineering Design at the School of Mechanical and Manufacturing Engineering, University of New South Wales. Dr. Liu is a Fellow of ASME (American Society of Mechanical Engineers), Associate Member of International Academy for Production Engineering (CIRP), Invitational Fellow of JSPS (Japan Society for the Promotion of Science), Fellow of the PLuS Alliance, and Senior Fellow of the Higher Education Academy (SFHEA). He is Secretary of CIRP Scientific Technical Committee on Design in 2022-2025. He received multiple prestigious awards such as UNSW Vice-Chancellor’ s Award for Outstanding Contributions to Student Learning, one of the 250 Top Researchers by the Australian's Research Magazine 2021-2023, Outstanding Contributions to Student Learning of the 2022 Australian Awards for University Teaching (AAUT).

Session on

Digital Twin Design (D)

Wednesday, October 16th 2024

Tencent ID: 967-819-238
https://meeting.tencent.com/dm/TJodVDGTwbSs

Milan Time	Beijing Time	Agenda
10:00	16:00	**D-1** How to plan a Digital Twin in Manufacturing with the Help of Enterprise Architecture Management Jonas LICK
10:30	16:30	**D-2** Force compliance control technology for axis and hole assembly process using dual robot collaboration Zhanxi WANG
11:00	17:00	**D-3** Vision Twin: The digital twin-based data augmentation for industrial machine visions and challenges in its realization Yuchen WANG
11:30	17:30	**D-4** Digital Manufacturing based on the Integration of Digital Twins and 5G / 6G Networks Dimitris MOURTZIS
12:00	18:00	**D-5** Enhancing Cylindricity Evaluation in Dimensional Metrology through Digital Twin Rim BENNOUNE, Nabil ANWER, Hichem NOUIRA, Mohamed DAMAK

Digital Twin Design (D-1)



Jonas Lick

Research associate,
Fraunhofer Institute for Mechatronic Systems Design (IEM) (Germany)

Title:

How to plan a Digital Twin in Manufacturing with the Help of Enterprise Architecture Management

Abstract

Digital Twins in Manufacturing becoming more important in today's manufacturing world, but many companies are struggling to plan for its successful implementation. This presentation suggests using an Enterprise Architecture Management approach to make this process easier and more effective. We propose an integrated planning approach, that is focused on helping practitioners in a real-world environment getting the Digital Twins into productive use. Our approach consists of the following phases: (1) Determine initial situation & target picture for the Digital Twin incl. deriving a short list of suitable use cases; (2) Company specific Digital Twin design; (3) Plan Enterprise Architecture changes. Based on the planning approach the presentation will give insights into DT-research projects we implemented and are currently working on at Fraunhofer IEM.

Digital Twin Design (D-2)



Zhanxi Wang

Dr., Associate Professor

Northwestern Polytechnical University (China)

Title:

Force compliance control technology for axis and hole assembly process using dual robot collaboration

Abstract

Precision peg-in-hole assembly is a common form of assembly in the manufacturing industry. There are both position constraints and force constraints in the assembly process. Therefore, the use of industrial robots to achieve automatic assembly of shaft holes has always been a challenging hot issue. Firstly, we propose the overall force control strategy for different contact states. Secondly, a force compliance control model with adaptive effect on environmental position and stiffness is established. The simulation results show that the control model can eliminate the steady-state error of the force tracking process. Then, the assembly simulation experiment is carried out to verify the force-position control effect of the dual-robot collaborative assembly under different robot position and attitude errors. Finally, a master-slave dual robot assembly experimental platform is built to verify the feasibility of the adaptive force compliance control model and the master-slave cooperative model.

Digital Twin Design (D-3)



Yuchen WANG

PhD Candidate,
Xi'an Jiaotong-Liverpool University (China)
University of Liverpool (UK)

Title:

Vision Twin: The digital twin-based data augmentation for industrial machine visions and challenges in its realization

Abstract

The importance of data augmentation for industrial machine vision cannot be overstated. While traditional methods focus on image conversion techniques, recent years have seen the emergence of data augmentation through simulations in virtual environments. This innovative approach offers a means to customize training datasets, enhancing sample efficiency. However, challenges such as the limited timeliness of training datasets and the arduous task of modeling virtual environments persist. This presentation introduces Vision Twin, a novel data augmentation method based on the concept of the digital twin. Vision Twin aims to improve data augmentation from three perspectives: (1) Enhancing dataset timeliness through regular twinning between physical and virtual environments; (2) Improving the autonomy of virtual modeling; (3) Enhancing sample efficiency through intelligent tuning of data augmentation strategies. The presentation will first outline the framework of Vision Twin, showcasing the bidirectional twining between physical and virtual environments. Additionally, it will delve into relevant research endeavors aimed at addressing critical challenges within Vision Twin, particularly focusing on deep learning and deep reinforcement learning-driven methods. Lastly, the presentation will discuss the future challenges and opportunities associated with the realization of Vision Twin's prospect.

Digital Twin Design (D-4)



Dimitris MOURTZIS

Professor

University of Patras (Greece)

Title:

Digital Manufacturing based on the Integration of Digital Twins and 5G / 6G Networks

Abstract

Despite the latest advances in Manufacturing and ICT (Information and Communication Technologies), data transmission and communication latency has posed a consistent challenge across various manufacturing fields. Although continuous advancements in communication protocols during Industry 4.0 have been achieved, latency persists, leading to diminished Quality of Service (QoS) and Quality of Experience (QoE). Addressing this challenge, the Tactile Internet, bolstered by the capabilities of Digital Twins and 6G networks, offers high availability, security, and ultra-fast response times, introducing a new dimension to Human-Machine Interaction (HMI) by enabling haptic and tactile sensations. In conjunction with the emerging 5G and 6G mobile communication networks, the Tactile Internet, fueled by Digital Twins, can serve as a backbone for latency reduction. This synergy is particularly valuable for ultra-reliable low-latency applications such as Smart and Digital Manufacturing, ushering in an era of enhanced performance and efficiency.

Digital Twin Design (D-5)



Rim BENNOUNE

CIFRE PhD student,
Laboratoire National de Métrologie et d' Essais (LNE-CNAM)
Université Paris-Saclay, ENS Paris-Saclay(France)

Title:

Enhancing Cylindricity Evaluation in Dimensional Metrology through Digital Twin

Abstract

Nanocyl is a cylindricity-measuring machine that applies the Dissociated Metrology Technique (DMT), achieving a measurement uncertainty lower than 40 nm. The objective of this research is to achieve lower uncertainty based on NanocylTwin, the digital twin of Nanocyl which is designed to meet this goal. The initial phase involves applying the ISO 23247 standard to map NanocylTwin requirements, identify and categorize each entity within the digital twin environment. This structured approach ensures a comprehensive and effective approach for NanocylTwin development and implementation, paving the way for significant advancements in dimensional metrology..

Digital Twin Additive Manufacturing（AM)

Chair



Kunpeng ZHU

Professor

Hefei Institutes of Physical Science, Chinese Academy of Sciences

Wuhan university of science and technology (China)

Co-Chair



Xin LIN

Professor

Wuhan university of science and technology (China)

Session on

Digital Twin Additive Manufacturing (AM)

Wednesday, October 16th 2024

Tencent ID: 164-366-392
https://meeting.tencent.com/dm/g8GbzX2NIl7J

Milan Time	Beijing Time	Agenda
15:00	21:00	**AM-1** Service oriented digital twin for additive manufacturing process Yunlong TANG
15:30	21:30	**AM-2** Deep Learning Empowered Additive Manufacturing Online Monitoring and Control Zhibin ZHAO
16:00	22:00	**AM-3** Digital Twin-driven On-line Monitoring Method of Laser Powder Bed Fusion Process Xianyin DUAN
16:30	22:30	**AM-4** Building Digital Twins for Additive Manufacturing Processes: from Macro to Micro Scale Yi CAI
17:00	23:00	**AM-5** A digital twin framework for melt pool monitoring of LPBF using machine learning with high-speed coaxial imaging and simulation data Yingjie ZHANG
17:30	23:30	**AM-6** A digital twin for track's morphology prediction by combining melt pool simulations with in-situ monitoring in metal additive manufacturing Xin LIN

Digital Twin Additive Manufacturing (AM-1)



Yunlong TANG

Lecturer,
Monash University (Australia)

Title:

Service oriented digital twin for additive manufacturing process

Abstract

Currently, Industry 4.0 is rapidly developing, empowered by IoT, cloud computing and AI. As two crucial components of Industry 4.0, digital twins and additive manufacturing (AM) are attracting increasing attention. Despite considerable research in recent years on developing digital twins for AM, the field still faces discrepancies in definition and confusion in development processes, making the development of AM digital twins expensive. The reason behind this is the uniqueness of each AM process, leading to low adaptability in AM digital twins. To address this issue, this talk summarises AM digital twins found in the literature review and proposes a novel, service-oriented framework comprising four layers: service, model, data, and interface. This framework aims to enhance the reusability of developed AM digital twins across various levels. The commonly used components in each layer are also summarised to assist developers in rapidly constructing AM digital twins tailored to their specific needs. A case study is included to demonstrate the framework’ s effectiveness and potential.

Digital Twin Additive Manufacturing (AM-2)



Zhibin ZHAO

Associate Professor,
Xi'an Jiaotong University (China)

Title:

Deep Learning Empowered Additive Manufacturing Online Monitoring and Control

Abstract

Although Deep Learning (DL) has shown great potential in the online monitoring and control of AM, the complexity of multi-physical field coupling and process flexibility in the AM process lacks a mature monitoring and control framework. To overcome these challenges, we propose a vision-based online monitoring and quality evaluation system for AM, as well as corresponding multi-parameter control strategies. This system innovatively integrates the following key technologies. First, a privacy-protected federated transfer learning framework is used to ensure data privacy while achieving effective knowledge transfer. Second, a multi-task collaborative online quality evaluation method is developed to improve the accuracy of the evaluation. Third, lightweight model via reparameterization is proposed to meet the real-time requirements of online monitoring. In addition, the system utilizes DL to achieve accurate prediction of the process parameters, and then combined with transfer learning technology, the system can effectively transfer the learned knowledge to new process parameter adjustments, significantly improving the quality stability of additive manufacturing by adjusting multiple key parameters online. Finally, we demonstrate the effectiveness and application potential of the proposed method through practical cases, including online monitoring and control of Laser Powder Bed Fusion (LPBF) powder spreading and Fused Deposition Modeling (FDM) systems, providing new perspectives and solutions for the further development of AM.

Digital Twin Additive Manufacturing (AM-3)



Xianyin DUAN

Associate Professor,
Wuhan University of Science and Technology (China)

Title:

Digital Twin-driven On-line Monitoring Method of Laser Powder Bed Fusion Process

Abstract

The field of laser powder bed fusion (LPBF) of metals is advancing towards greater precision, efficiency, and intelligence. However, the extreme thermal conditions of the laser melting process have led to persistent quality defects in the fabricated parts, limiting the widespread application of LPBF technology. To address these challenges and produce high-quality parts, it is crucial to implement on-line monitoring and process control during manufacturing. This talk describes a digital twin-driven on-line monitoring method for the metal LPBF process. This method aims to establish an intelligent manufacturing system and perform case analysis. By integrating physical and virtual models of the powder melting process, on-line process monitoring, and big data analysis, a comprehensive digital twin system for the on-line monitoring of the building process is developed. This system encompasses the equipment layer, data conversion layer, network layer, control layer, and application layer. The talk details the functions and key technologies of each layer and provides analysis of typical application examples in selective laser melting (SLM) process monitoring. This approach offers theoretical and technical support for the intelligent manufacturing based on LPBF technology.

Digital Twin Additive Manufacturing (AM-4)



Yi CAI

Associate Professor,
The Hong Kong University of Science and Technology (China)

Title:

Building Digital Twins for Additive Manufacturing Processes: from Macro to Micro Scale

Abstract

This presentation covers two representative projects of building digital twins for different additive manufacturing processes. The first project is focused on macro-scale additive manufacturing using multi-robot collaboration. A virtual manufacturing system is developed where different configurations of multiple robots can be created and simulated for concurrent deposition. A method based on augmented reality is developed to connect physical robots and virtual robots so that simulation scenarios can be automatically established, and simulation results can be efficiently implemented. The second project is developed upon micro-scale inkjet-based additive manufacturing process. Based on in-situ video data, a tri-level digital twin framework is established for inkjet-based additive manufacturing. Inspection and closed-loop control are implemented to ink droplets, printed patterns, and final product, respectively.

Digital Twin Additive Manufacturing (AM-5)



Yuxin ZHANG

Associate Professor,
South China University of Technology (China)

Title:

A digital twin framework for melt pool monitoring of LPBF using machine learning with high-speed coaxial imaging and simulation data

Abstract

Digital twin technology is crucial for advancing intelligent manufacturing by ensuring product quality, reducing costs, and enhancing efficiency. In Laser Powder Bed Fusion (LPBF), Digital Twin technology provides a robust solution for predicting part characteristics, diagnosing defects, and controlling processes. This study introduces a sensor and simulation combined digital twin (SSC-DT) framework that monitors molten pool characteristics—such as width, depth, and mean temperature—by integrating in-situ sensor data with physical simulation data.

Experimental results show that the SSC-DT framework achieves a mean relative error of less than 10% compared to optical microscope (OM) measurements. Notably, the predicted molten pool depth error from SSC-DT is lower than those calculated by the Eagar-Tsai model, keyhole empirical model, and finite element method (FEM). Consequently, SSC-DT predictions closely align with actual sensor data under conduction and slight keyhole modes of the molten pool, supporting intelligent control, predictive maintenance, and quality assurance in future LPBF processes.

Digital Twin Additive Manufacturing (AM-6)



Xin LIN

Professor,
Wuhan university of science and technology (China)

Title:

A digital twin for track’s morphology prediction by combining melt pool simulations with in-situ monitoring in metal additive manufacturing

Abstract

Although many works have created so-called 'digital twins' for Laser Powder Bed Fusion (LPBF) that track changes during processing in response to in-situ monitoring data, these predictions cannot satisfy online control requirements due to the uncertainty of the model and data, as well as the absence of bidirectional communication between the digital and physical twins. We propose a digital twin (DT) framework that integrates in-situ monitoring data and simulation to predict real-time imperfections of the as-built track. The graph convolutional network (GCN) is proposed to predict the as-built track's morphology based on images collected by a CMOS camera. Simulation is utilized to imitate a series of physical phenomena such as melting, solidification, evaporation, and track morphology via a coupled Computational Fluid Dynamics-Discrete Element Method (CFD-DEM) approach. Furthermore, a Bayesian probability method is proposed to estimate simulation model parameters and the track’s imperfections. This approach aims to address the problem of unmeasured state variable values and uncertainty in digital simulation models, subsequently bidirectionally correcting the parameters of both the simulation and prediction models based on in-situ monitoring data. Ultimately, the goal is to achieve online defect prediction, process adjustment, and minimization of imperfections.

Digital Twin Energy Intelligence （EI）

Chair



Xuhui ZHANG

Professor

Xi'an University of Science and Technology (China)

Co-Chair



Xuewen WANG

Professor

Taiyuan University of Technology (China)



Yinan GUO

Professor

China University of Mining & Technology (China)

Session on

Digital Twin Energy Intelligence (EI)

Tuesday, October 15th 2024

Tencent ID: 425-418-722
https://meeting.tencent.com/dm/g7MwDlhY0oo7

Milan Time	Beijing Time	Agenda
14:00	20:00	**EI-1** DT-driven Virtual tunning and decision control of underground mining Xuhui ZHANG
14:30	20:30	**EI-2** Key technologies for digital twin in smart coal mines Yinan GUO
15:00	21:00	**EI-3** Virtual Testing Method for Explosion Proof Performance of Coal Mine Equipment Driven by Multi source Data Xusheng XUE
15:30	21:30	**EI-4** Virtual-reality interaction control method for cantilever roadheader driven by digital twin Yan WANG
16:00	22:00	**EI-5** Key technologies and application exploration of industrial digital twin system for grinding and mining Equipment Haoqi WANG
16:30	22:30	**EI-6** XR intelligent operation and maintenance system for complex human-robot collaboration tasks in coal mines Shuguang LIU
17:00	23:00	**EI-7** A Digital Twin-based Bi-directional Deduction Method for the Full-pose of the Floating Connection Mechanism Suhua LI
17:30	23:30	**EI-8** Application of Digital Twin for industrial process control: A case study of gauge-looper-tension optimized control in strip hot rolling Jie SUN

Digital Twin Energy Intelligence （EI-1）



Xuhui ZHANG

Professor,
Xi'an University of Science and Technology (China)

Title:

DT-driven Virtual tunning and decision control of underground mining

Abstract

The traditional automatic control method is difficult to adapt to the complex underground environment, and the debugging of the control system is difficult. With the help of digital twin, visual pose measurement, robot control and other technologies, the research on the virtual debugging and decision control method of the section forming process of mining equipment strongly supports the national strategic orientation of unmanned operation in coal mines. Through the construction of the driving equipment intelligence agent, the deep reinforcement learning algorithm is used to realize the autonomous decision-making of the driving equipment section forming in the unknown environment under complex working conditions, achieve the autonomous decision-making within the specified step size, and obtain the high-precision cutting trajectory of the section forming. A virtual debugging platform was built, and virtual debugging and application experiments were carried out. The experimental results showed the feasibility of the system and provided a new technical idea for the intelligent control of underground driving equipment.

Digital Twin Energy Intelligence （EI-2)



Yinan GUO

Professor,
China University of Mining & Technology (China)

Title:

Key technologies for digital twin in smart coal mines

Abstract

Digital twin plays a core role in improving the intelligence of a coal mine. Facing various mining processes, different decision-making and control problems are emerged in digital twin-based intelligent platforms for mining coal. Based on this, an architecture of digital twin-based intelligent platforms is first illustrated. Then, key technologies in mining coal and excavating a roadway, as well as the transportation system are analyzed, respectively. A five-dimensional digital twin model is built for the intelligent mining workface, and knowledge-guided autonomous virtual-real interaction method is put forward. Especially, three classification methods for data streams stemmed from cutting part in a shearer are presented to analyze the coupling relationship between the characteristics of cutting part in a shearer and rock seam. Digital twin-based control strategies are put forward to guarantee the reliable temporary and permanent support for the roof of a roadway. Finally, a digital twin-based transportation platform for open-pit mine is given and the planning method for its haulage systems is presented.

Digital Twin Energy Intelligence （EI-3)



Xusheng XUE

Associate Professor (PhD),
Xi’ an University of Science and Technology(China)

Title:

Virtual Testing Method for Explosion Proof Performance of Coal Mine Equipment Driven by Multi source Data

Abstract

The explosion-proof performance of coal mine equipment is an important premise to ensure coal mine safety production. At present, affected by the environmental conditions of coal mine equipment explosion-proof performance testing, the problems of single information, difficult to capture, and invisibility in the performance testing process lead to long detection cycle, low efficiency, and high cost of coal mine equipment explosion-proof performance testing. Therefore, it is urgent to study the virtual detection method of coal mine equipment explosion-proof performance driven by multi-source data. The mapping relationship between the characteristic parameters of coal mine explosion-proof equipment and the digital twin is studied, the multidimensional perception method of the physical entity and environmental characteristics of coal mine explosion-proof equipment is constructed, the correlation data set of the physical entity characteristic multidimensional data of coal mine explosion-proof equipment and the digital twin characteristic parameters is established, and the digital twin measurement system of coal mine explosion-proof equipment based on the data set is developed. This method effectively realizes the virtualization of the internal explosion propagation test measurement of coal mine equipment, improves the detection efficiency of the explosion-proof performance of coal mine equipment and reduces the cost, and provides the basis for the green design and manufacture of coal mine equipment.

Digital Twin Energy Intelligence （EI-4)



Yan WANG

Lecturer,
Xi’ an University of Science and Technology (China)

Title:

Virtual-reality interaction control method for cantilever roadheader driven by digital twin

Abstract

Due to the time-delay caused by sensor data acquisition, signal processing, and network communication, the digital space and physical space cannot achieve absolute synchronization of virtual-real information decision-making. The accumulation of these time delays may result in a reduction in the timeliness of the decision-making in the digital space. Aiming at the current demand for real-time and reliability of intelligent control of cantilever roadheader, a virtual-real interactive control method for cantilever roadheader driven by digital twin is proposed, which plays the advantages of virtual control in decision-making security boundary and physical control in decision-making real-time. Firstly, the five-dimensional model architecture of virtual-real interaction control for cantilever roadheader is constructed, and the logical relationship between digital space and physical space is sorted out to realize the fusion of virtual-real interaction control decision-making; on this basis, the mathematical descriptive model of virtual-real interaction control is constructed, and the effect of virtual-real interaction time delay on the fusion control decision-making of the roadheader is analyzed; furtherly, the execution logic architecture of the virtual-real interaction fusion control model of the roadheader considering time-delay characteristics is established, and the inherent delay effect on the virtual-real interaction control of the roadheader is reduced through the processes of "state alignment", "evolution prediction" and "decision fusion". Finally, the shaping quality evaluation of the roadway is examined to verify the effectiveness of the proposed virtual-real interaction fusion control method.

Digital Twin Energy Intelligence （EI-5)



Haoqi WANG

Professor,
Zhengzhou University of Light Industry (China)

Title:

Key technologies and application exploration of industrial digital twin system for grinding and mining equipment

Abstract

High-end equipment, such as large-scale mineral grinding and mining equipment, is the key equipment for Chinese economic pillar industries of mining and coal, and has the characteristics of high value, multiple equipment coordination, many control and operation points, and harsh operating environment. Among them, large-scale grinding equipment occupies the core link in the industrial chain and its investment and energy consumption account for more than 70% of the mineral processing process. Energy saving optimization is the key to achieving the intelligent transformation of coal mining equipment, and digital twin provides an effective approach. Digital twin is expanding from local digital twin scenarios of mechanical equipment to the industrial digital twin system (iDTS) of "human-machine-environment" integration. This presentation first introduces the characteristics and reference architecture of the industrial digital twin system (iDTS) for coal mining equipment. Then, it introduces relevant key technologies, including multi-physical field simulation, multi-modal perception and intelligent interaction methods, and AI agent-based system self-learning and optimization control methods. Finally, it shares practical exploration cases, , including the virtual-real mapping of the scraper conveyor S-bend based on digital twin, the energy-saving regulation of the large vertical mill based on multi-physical field simulation, and the optimization design of the impact crusher for dust and energy saving.

Digital Twin Energy Intelligence （EI-6)



Shuguang LIU

Ph.D. Student,
Taiyuan University of Technology (China)

Title:

XR intelligent operation and maintenance system for complex human-robot collaboration tasks in coal mines

Abstract

With the development of coal mine intelligence and the development and application of coal mine robots, efficient collaboration between coal mine operators and coal mine robots plays a vital role in complex underground tasks. Aiming at the complex scenarios of multi-person and multi-robot collaboration in coal mine auxiliary operation, a coal mine XR intelligent operation and maintenance system was established to empower the collaboration between two types of operators (including central control operators and field control operators) and two types of robots (including detection robots and operation robots). The VR operation and maintenance subsystem, AR operation and maintenance subsystem, and communication network were constructed respectively. Through the collaborative operation of the VR/AR operation and maintenance subsystems with coal mine operators and coal mine robots, coordinated perception, decision-making, and control in both virtual and physical spaces can be achieved. This allows for the simulation, iteration, optimization, and verification of complex tasks in the physical space within the virtual space, forming an intelligent operation model of human-human, human-machine, and machine-machine interaction and collaboration. It not only provides a new approach and paradigm for human-robot collaboration in complex mining tasks, but also serves as a general reference for similar application scenarios in other industries. It not only provides a new approach and paradigm for human-robot collaboration in complex mining tasks, but also serves as a general reference for similar application scenarios in other industries.

Digital Twin Energy Intelligence （EI-7）



Suhua LI

Ph.D. Student,
Taiyuan University of Technology (China)

Title:

A Digital Twin-based Bi-directional Deduction Method for the Full-pose of the Floating Connection Mechanism

Abstract

The pose of the equipment connected using the Floating Connection Mechanism (FCM) is closely related to the straightness of the fully-mechanized mining face. However, the current monitoring of equipment posture still exists in the blind zone, unreliable sensing data, etc. Therefore, We proposes a digital twin-based bi-directional deduction method for the pose of starting/end point of the FCM. Firstly, considering the pose of the connection equipment, an optimization of the motion law of the FCM based on Conformal Geometry Algebra (CGA) is realized; secondly, based on the motion law and the structural character of the equipment, both the real-time solution of the end pose and the virtual application of optimization motion laws of the FCM are achieved by marking key points and extracting key information; then, referring to the information enhancement scheme obtained by adding digital twin sensors enhancement and a bi-directional deduction method is proposed for the virtual-real fusion of the pose of the starting/end point of the FCM; finally, the experimental validation shows that the motion law of the FCM proposed in this paper is in line with the actual motion and generates better analytical results.

Digital Twin Energy Intelligence （EI-8)



Jie SUN

Professor,
Northeastern University (China)

Title:

Application of Digital Twin for industrial process control: A case study of gauge-looper-tension optimized control in strip hot rolling

Abstract

During the hot rolling process, the performance of most control systems gradually degrades due to equipment aging and changing process conditions. However, existing gauge-looper-tension control method remain restricted by a lack of intelligent parameter maintenance strategies. To address this challenge and enhance the smart manufacturing capabilities of strip hot rolling, based on the digital twin method, this paper proposes a data-driven optimized control method for the gauge-looper-tension system of strip hot rolling. First, a hot rolling process model is constructed based on a digital twin method to serve as an evaluation and optimization platform. Subsequently, relevant data are collected to calculate the Hurst index for identifying the performance of the controller during the rolling process. Additionally, for controllers with poor Hurst index values, the crayfish optimization algorithm is employed for adjusting controller parameters to maximum the Hurst index. Experimental results demonstrate that the evaluation method effectively recognized the control state of gauge-looper-tension system and the optimization method successfully enhances the performance of the control system. Therefore, based on the digital twin platform, the proposed method can effectively maintain performance-degraded control systems.

Digital Twin Smart Construction （SC）

Chair



Zhansheng LIU

Professor

Beijing University of Technology (China)

Co-Chair



Zhe SUN

Assistant Professor

Beijing University of Technology (China)



Fengjuan CHEN

Associate Professor

Beijing University of Technology (China)

Session on

Digital Twin Smart Construction (SC)

Tuesday, October 15th 2024

Tencent ID: 258-954-982
https://meeting.tencent.com/dm/pNV2X673DQCZ

Milan Time	Beijing Time	Agenda
14:00	20:00	**SC-1** Enhancing Nuclear Power Production with Digital Twin and Artificial Intelligence Kefu LV
14:30	20:30	**SC-2** Digital Twins Supporting Decommissioning of Heavy Water Research Reactor Yu ZHANG
15:00	21:00	**SC-3** Solution of Digital Twin Application in Supply Chain of Manufacturing Enterprises Shen ZHANG
15:30	21:30	**SC-4** Leveraging Artificial Intelligence for Predictive Analysis of Pavement Condition and Maintenance Costs in the Context of Natural Hazards Yanyu WANG
16:00	22:00	**SC-5** The Application of Digital Twins in Infrastructure Weiwei CHEN
16:30	22:30	**SC-6** Building of A Digital Platform for Intelligent Construction of Civil Engineering Structures Fengjuan CHEN
17:00	23:00	**SC-7** Solution of Digital Twin Application in Supply Chain of Manufacturing Enterprises Jiaqi LI

Digital Twin Smart Construction （SC-1)



Kefu LV

Engineer,
China National Nuclear Corporation (China)

Title:

Enhancing Nuclear Power Production with Digital Twin and Artificial Intelligence

Abstract

Integrating artificial intelligence (AI) with digital twin technology offers transformative potential for enhancing nuclear power production. Digital twins create precise virtual models of physical assets, while AI enhances these models with real-time data analysis, predictive maintenance, and process optimization. This combination boosts operational efficiency, safety, and reliability in nuclear power plants. AI-driven insights, supported by digital twins, can streamline maintenance, optimize energy output, and improve overall plant management. As advancements continue, particularly in explainable AI, the synergy of these technologies is poised to revolutionize nuclear energy, driving innovation and regulatory developments in the industry.

Digital Twin Smart Construction （SC-2)



Yu ZHANG

Senior Engineer,
China Institute of Atomic Energy (China)

Title:

Digital Twins Supporting Decommissioning of Heavy Water Research Reactor

Abstract

Heavy Water Research Reactor (HWRR) is the first reactor in China. According to the plan of China Institute of Atomic Energy (CIAE), immediate dismantling is selected as the strategy of HWRR decommissioning. Nuclear reactor decommissioning is a complex engineering. Digital Twins of nuclear facilities recreate a facility’s technology and structures and support effective design, operation, and maintenance. This research puts forward digital twins technology application in HWRR decommissioning, supporting the characterization, dismantling, and radioactive waste management.

Digital Twin Smart Construction （SC-3)



Shen ZHANG

Chairman, Zhongda Digital Company
Digital Director, Central South Architectural Design Institute (China)

Title:

Solution of Digital Twin Application in Supply Chain of Manufacturing Enterprises

Abstract

An intelligent construction platform is built with industrial software as the core to revolutionize the traditional project management, break down data silos, realize the whole process collaboration, and "one model to the end, construction with no drawing, and full-process transparency". According to practices, the platform effectively improves the construction period, costs and project quality to lead the construction industry to digital transformation, and drive deep integration of the industrial chain.

Digital Twin Smart Construction （SC-4)



Yanyu WANG

Assistant Professor,
Louisiana State University (US)

Title:

Leveraging Artificial Intelligence for Predictive Analysis of Pavement Condition and Maintenance Costs in the Context of Natural Hazards

Abstract

Natural hazards significantly impact pavement integrity and maintenance costs, posing challenges to infrastructure management. This research integrates artificial intelligence (AI) to analyze a dataset of 100 records on natural hazards, pavement conditions, and maintenance costs. By utilizing machine learning models, the study aims to predict pavement deterioration and estimate future maintenance expenses, enabling proactive planning. The AI-driven models will consider factors like hazard type, pavement materials, traffic load, and maintenance history. The findings will provide infrastructure managers with insights to optimize maintenance strategies, reduce costs, and improve pavement resilience, advancing the role of AI in civil infrastructure management.

Digital Twin Smart Construction （SC-5)



Weiwei CHEN

Assistant Professor,
University College London (UK)

Title:

The Application of Digital Twins in Infrastructure

Abstract

The construction industry is currently grappling with issues such as low productivity, labour shortages, and frequent safety incidents. In this context, the applications of intelligent construction and digital twins have garnered widespread attention from both academia and industry. Digital twin technology, as one of the primary core technologies of intelligent construction, combined with sensing technology, AI and machine learning, holds promise in effectively addressing challenges such as 3D reconstruction, real-time monitoring, predictive maintenance and net zero carbon. This report primarily explores the application of digital twin technology in infrastructures, especially for construction and maintenance. Through real-world case studies, this report showcases the value and impact of digital twins in the realm of intelligent and sustainable construction.

Digital Twin Smart Construction （SC-6)



Fengjuan CHEN

Associate Professor,
Beijing University of Technology (China)

Title:

Building of A Digital Platform for Intelligent Construction of Civil Engineering Structures

Abstract

Construction of a digital platform for intelligent construction of civil engineering structures relies on physical models and mathematical algorithms. Utilizing BIM modeling, multidimensional digital modeling, and advanced simulation technologies, the built digital platform integrates big data and intelligent decision support systems. Notable applications include the design and case analysis of the Beijing Daxing International Airport, the Beijing Winter Olympics venues, and digital simulations for nuclear reactor decommissioning projects, demonstrating comprehensive capabilities in enhancing construction efficiency and safety through advanced digitalization.

Digital Twin Smart Construction （SC-7)



Jiaqi LI

Product Manager

Huaru Technology (China)

Title:

Solution of Digital Twin Application in Supply Chain of Manufacturing Enterprises

Abstract

The digital upgrading of the supply chain is a megatrend and direction for enterprise development. This talk will present the current status and pain points of manufacturing enterprise supply chains, and combine a digital twin construction method to introduce the solution and technical route of "simulation+intelligent decision-making" empowering the digital transformation of enterprise supply chain.

Digital Twin Reliability （R）

Chair



Yi REN

Professor

Beihang University (China)

Co-Chair



Cheng QIAN

Associate Professor

Beihang University (China)



He LI

Assistant Professor

University of Lisbon (Portugal)

Session on

Digital Twin Reliability (R)

Wednesday, October 16th 2024

Tencent ID: 443-161-146
https://meeting.tencent.com/dm/nQa67dZiRDFs

Milan Time	Beijing Time	Agenda
15:00	21:00	**R-1** Digital Twins for Smart Firefighting and Evacuation Xinyan HUANG
15:30	21:30	**R-2** Thermal and Thermal-Mechanical Oriented Reliability Co-design of SiC Power Device Panel-level Packaging Jiajie FAN
16:00	22:00	**R-3** Multi-Robot Swarming: Cooperation and Competition Shiyu ZHAO
16:30	22:30	**R-4** Digital Twin-Enabled Decision-Making for Multi-UAV Autonomous Recovery Oriented to Resilience Xingsuo HAI
17:00	23:00	**R-5** Data-driven Stochastic Model Updating with Conditional Invertible Neural Networks (cINN) Sifeng BI
17:30	23:30	**R-6** Electro-Thermal Digital Twin for Power Modules Temperature Characterization during Power Cycling Tests Zhongchao SUN
18:00	24:00	**R-7** Data synchronization for reliable Digital Twins Mama DIAKITÉ, Mamadou Kaba TRAORÉ

Digital Twin Reliability （R-1)



Xinyan HUANG

Associate Professor,
The Hong Kong Polytechnic University (China)

Title:

Digital Twins for Smart Firefighting and Evacuation

Abstract

Over the past decade, big data, Artificial Intelligence, and digital twin have enabled new approaches to improve fire safety. The emerging applications of AI and digital twins enable more intelligent fire detection, fire hazard assessment and real-time fire forecast. This talk will introduce the digital twin future framework for combining AI, sensor networks and intelligent robots to help forecast and fight fire, as well as safe evacuation in fire incidents. I will also talk about the guidelines for constructing a reliable fire database, propose new concepts for building Fire Digital Twin, and review deep learning algorithms that enable super real-time fire quantification, forecast of fire development, and robotic firefighting.

Digital Twin Reliability （R-2)



Jiajie FAN

Youth Professor,
Fudan University (China)

Title:

Thermal and Thermal-Mechanical Oriented Reliability Co-design of SiC Power Device Panel-level Packaging

Abstract

Silicon Carbide Metal Oxide Semiconductor Field Effect Transistor (SiC MOSFET) is mainly characterized by a higher electric breakdown field, higher thermal conductivity and lower switching loss enabling high breakdown voltage, high-temperature operation and high switching frequency. However, their performances are considerably limited by the high parasitic inductance and poor heat dissipation capabilities associated with existing wire-bonding packaging methods. A new panel-level SiC MOSFET power module is developed by using the Fan-Out and embedded chip technologies. To achieve the more effective thermal management and higher reliability under thermal cycling, some optimization methods, i.e. Ant colony optimization-Back Propagation neural network (ACO-BPNN), non-dominated sorting genetic algorithm (NSGA-II) and the improved multi-objective particle swarm optimization algorithm (MOPSO) will be introduced for optimizing the new design of SiC modules, and contrast it with the traditional Response Surface Method (RSM).

Digital Twin Reliability （R-3)



Shiyu ZHAO

Associate Professor,
Westlake University (China)

Title:

Multi-Robot Swarming: Cooperation and Competition

Abstract

Multi-robot swarming is a core research area in the field of robotics. It has also been recognized as one of the ten grand challenges in robotics. In this talk, I will introduce the research progress of the Intelligent Unmanned Systems Laboratory over the past few years. Multi-robot swarming tasks can be classified as cooperative or competitive. Regarding cooperative multi-robot swarming, I will talk about our recent research on a classic benchmark problem in multi-robot swarming: shape assembly. Regarding competitive multi-robot swarming, I will talk about our research work in the field of aerial target pursuit, particularly a series of vision-based motion estimation algorithms and systems.

Digital Twin Reliability （R-4)



Xingsuo HAI

Research Fellow,
Nanyang Technological University (Singapore)

Title:

Digital Twin-Enabled Decision-Making for Multi-UAV Autonomous Recovery Oriented to Resilience

Abstract

Real-time decision-making for multiple unmanned aerial vehicles (multi-UAV) mission planning is crucial but challenging due to unexpected disruptions. We propose a resilience-oriented decision-making framework that enables UAVs to generate autonomous recovery strategies in real time. A novel resilience metric is introduced, considering variances in mission completion rate and remaining resource inventory. On this basis, a resilience-oriented joint optimization model is formulated, incorporating maintenance and task reassignment as recovery strategies following accidental failures to UAVs. The optimization problem is formulated as a partially observable Markov decision process (POMDP) and solved using a modified multiagent deep Q network (MADQN) algorithm with enhanced learning efficiency. To leverage real-world experiences, digital twin-enabled technology is adopted for training, where each agent interacts with the DT environment using original and target networks to acquire an optimal assignment strategy. Simulations validate the effectiveness of the proposed methods.

Digital Twin Reliability （R-5)



Sifeng BI

Assistant Professor,
University of Southampton (UK)

Title:

Data-driven Stochastic Model Updating with Conditional Invertible Neural Networks (cINN)

Abstract

This work focuses on a data-driven version of the model updating process. A recently developed conditional invertible neural networks (cINN)-based architecture has been adopted in this work to achieve the multilevel Bayesian updating. Unlike the conventional approaches that employ the artificial neural networks (ANN) solely as a forward surrogate during model updating, the cINN-based model updating is a framework that performs as a bidirectional network where the forward training and inverse calibration are integrated into a uniform structure. The cINN consists of two parts known as the conditional network and the invertible neural network (INN). Both networks are trained jointly in the forward direction and can operate inversely to offer rapid and accurate predictions by given observation data. The application of the cINN provides a more efficient and direct manner to solve model updating problems without calculating the likelihood function, compared to the conventional Bayesian model updating. The cINN is employed to establish the multilevel Bayesian interface, enabling the updating process to be conducted in a stochastic manner. Rather than directly calibrating physical parameters, this approach focuses on the calibration of their statistical moments, e.g. mean and variance, referred to as hyperparameters. The hyperparameters are then utilized to determine the Probability of Damage (PoD), which provides a confidence level about the structural condition, facilitating stochastic damage detection. Two case studies are proposed to demonstrate the multilevel cINN-based stochastic damage detection approach. The first involves a 3-degree-of-freedom (3-DOF) spring-mass simulation model, while the second case study employs an experimental rig testcase with practical measurements, each under various damage scenarios.

Digital Twin Reliability （R-6)



Zhongchao SUN

PhD candidate,
Aalborg University (Denmark)

Title:

Electro-Thermal Digital Twin for Power Modules Temperature Characterization during Power Cycling Tests

Abstract

The thermal behavior of power modules significantly impacts their power cycling lifetime by influencing power loss generation in the electrical domain and subsequently altering the temperature response. This study introduces a coupled electro-thermal digital twin designed to accurately predict the junction temperature during power cycling tests of wide band gap power modules and to provide detailed insights into the package's internal temperature distribution. The implementation was achieved through the integration of LTspice and COMSOL simulations governed by MATLAB scripts. Moreover, the proposed digital twin is compatible with enhanced electrical schematics by including parasitic and switch loss effects. It also supports the incorporation of innovative packaging patterns for comprehensive thermal analysis and extended thermo-mechanical analysis to identify the degradation mechanisms of critical packaging components.

Digital Twin Reliability （R-7）



Mama DIAKITÉ

PhD student,
the University of Bordeaux (France)

Title:

Data synchronization for reliable Digital Twins

Abstract

Data synchronization between a Digital Twin and its corresponding real system is a key feature of the Digital Twin concept, as it is what allows the Digital Twin model to be a faithful representation of the system of concern. However, no academic studies have been devoted to understanding the impact of such a synchronization on the quality and reliability of the Digital Twin's services. This presentation provides a conceptualization of the problem, and suggest, through a case study, how a sensitivity analysis approach can be formalized to address the issue.

Digital Twin Smart Engineering （SE）

Chair



Ying LIU

Professor

Cardiff University (UK)

Co-Chair



Yu ZHENG

Professor

Shanghai Jiaotong University (China)



Xiao GUO

Associate Professor

Cardiff University (UK)



Xiaohui CHEN

Professor

Chongqing University (China)



Sibao WANG

Professor

Chongqing University (China)

Session on

Digital Twin Smart Engineering (SE)

Tuesday, October 15th 2024

Tencent ID: 365-877-085
https://meeting.tencent.com/dm/DgPoULWhQl3y

Milan Time	Beijing Time	Agenda
14:00	20:00	**SE-1** Advancing Digital Twin Technology for Steam Turbine Generators: Real-Time Simulation and DEH Systems Xiao GUO
14:30	20:30	**SE-2** High-fidelity Digital Twin Modelling for Predictive Maintenance: State-of-the-art Yuhan LIU
15:00	21:00	**SE-3** Hybrid Digital Twins for Energy Optimization and Flexible Manufacturing in SMEs Jonas SCHMID
15:30	21:30	**SE-4** Digital Twin-Enhanced Decision Support in Seaport Operations: Framework and Case Studies Yuxuan ZHANG
16:00	22:00	**SE-5** Adaptive Control of Five-axis Milling Quality for Thin-walled Parts based on Digital Twins Sibao WANG
16:30	22:30	**SE-6** Precise Digital Twin Modeling of Intelligent Maintenance and Operation for Subway Door Electromechanical Coupling System Xiaohui CHEN
17:00	23:00	**SE-7** A digital twin-driven Wear Prediction Method of Carbon Strip for Urban Rail Vehicle Pantograph by Digital Twin Wennian YU
17:30	23:30	**SE-8** Deep Interpretable Network-Based Digital Twin Model for Pantograph-Catenary Wear Prediction Yizhen PENG

Digital Twin Smart Engineering （SE-1）



Xiao GUO

Associate Professor,
Cardiff University (UK)

Title:

Advancing Digital Twin Technology for Steam Turbine Generators: Real-Time Simulation and DEH Systems

Abstract

This speech will delve into the latest advancements in real-time simulation and Digital Twin (DT) technology for steam turbine generators, with a focus on Digital Electro-Hydraulic (DEH) systems. The presentation will highlight how real-time digital twin models enhance critical operational tasks, including system monitoring, fault prediction, and performance optimization. The discussion will explore the development of dynamic mathematical models, integration of 3D visualization, and the creation of real-time simulation platforms. Emphasis will be placed on both the technical methods and the practical implementation of these systems in improving efficiency, reliability, and safety, while also addressing key challenges and future research directions in digital twin applications for thermal power plants.

Digital Twin Smart Engineering （SE-2)



Yuhan LIU

PhD Student,
Cardiff University (UK)

Title:

High-fidelity Digital Twin Modelling for Predictive Maintenance: State-of-the-art

Abstract

This speech will explore the the state-of-the-art of high-fidelity digital twin (DT) modelling in predictive maintenance (PdM). The presentation will focus on how high-fidelity DT modeling enhances three critical PdM tasks: health indicator estimation, remaining useful life prediction, and fault diagnosis. The discussion will cover both the modelling methods and the process of integrating these methods into DT-driven predictive analytics, highlighting the benefits and identifying challenges and future research opportunities in this field.

Digital Twin Smart Engineering （SE-3)



Jonas SCHMID

Master Student,
Albstadt-Sigmaringen University (Germany)

Title:

Hybrid Digital Twins for Energy Optimization and Flexible Manufacturing in SMEs

Abstract

This speech will focus on the emerging role of hybrid-modeled Digital Twin (DT) systems in driving energy optimization and enhancing flexibility within manufacturing systems, particularly for small and medium-sized enterprises (SMEs). By integrating data-driven and physics-based modeling techniques, hybrid DTs can offer enhanced precision in monitoring, simulation, and decision-making. The discussion will highlight the Asset Administration Shell (AAS) standard as a foundation for creating Industry 4.0-compliant DTs, which support sustainable energy management and operational efficiency. A real-world use case from the electronics industry, specifically in Surface Mount Technology (SMT) Printed-Circuit Board (PCB) assembly lines, will be explored to showcase the practical benefits and challenges of adopting this approach. Finally, this presentation will outline future research directions to further optimize hybrid DTs for SMEs.

Digital Twin Smart Engineering （SE-4)



Yuxuan ZHANG

PhD student,
Shanghai Jiao Tong University (China)

Title:

Digital Twin-Enhanced Decision Support in Seaport Operations: Framework and Case Studies

Abstract

This speech will explore the implementation of Digital Twin (DT) technology in seaport operations. A comprehensive DT framework for seaports will be introduced, with real-time data integration and virtual modeling being highlighted. The discussion will then focus on two specific applications: integrated scheduling in automated container terminals and storage tank scheduling in liquid bulk terminals. How DT enhances decision-making, improves efficiency, and optimizes resource allocation in these contexts will be demonstrated. Implementation challenges and future research directions in seaport DT systems will also be addressed. The technology's potential to transform seaport operations through real-time monitoring, simulation, and adaptive optimization will be emphasized.

Digital Twin Smart Engineering （SE-5)



Sibao WANG

Professor,
Chongqing University (China)

Title:

Adaptive Control of Five-axis Milling Quality for Thin-walled Parts based on Digital Twins

Abstract

Processing quality prediction and control is of great significance to improve product performance, reduce cost and optimize resource utilization. This speech presents a digital twin system for five-axis machining, and real-time control of machining quality in five-axis milling of thin-walled parts. Firstly, a four-dimension, eight-level, five-axis machining digital twin frame is proposed, which includes geometric dimension, kinematic dimension, data-driven dimension and physical dimension. Secondly, an online prediction method for thin-walled blade milling surface roughness based on wavelet transform and convolutional neural network is proposed. The online prediction delay of machined surface roughness is as low as 340ms, and the prediction accuracy can reach 90%, which is more than 4.5% higher than the traditional neural network model. Then, a surface roughness consistency control method for machining signal stabilization is proposed. Finally, a 5-axis machine tool digital twin software is developed based on C++ and OpenGL. Using tinyobj library to load the five-axis machine tool geometric model, using OpenGL to render the model, based on TCP communication in the numerical control system to drive the geometric model movement in real time. The digital twin system is experimentally verified by taking five-axis machining of thin-walled blades as an example. The fluctuation range of blade surface roughness is reduced from 0.5 to 0.1μm, and the real-time performance of machining parameter adjustment is as high as 15ms.

Digital Twin Smart Engineering （SE-6)



Xiaohui CHEN

Professor,
Chongqing University (China)

Title:

Precise Digital Twin Modeling of Intelligent Maintenance and Operation for Subway Door Electromechanical Coupling System

Abstract

In response to the difficulty of online prediction of the operating status of the subway door transmission system, A precise digital twin modeling was built according to the operating status. Firstly, based on the physical mechanism, determine the coupling relationship of key components in the system, clarify the input-output mapping relationship of single component, and use system dynamics build the simulation model of the car door transmission system. The intermediate state variables and output variables of the system are obtained by given system inputs to simulate the behavior of real doors, circular working process. Secondly, to address the issue of dynamic model solidification, a twin model update mechanism based on pattern search algorithm is designed, which considers the tracking problem of the model as adaptive updating of state parameters to ensure mirror consistency between the virtual model and the actual system. Finally, using sensor measured data and virtual state parameters to construct twins dataset, combined with random forest algorithm to evaluate and reduce the importance of multi-source high-dimensional data features, and using Informer deep learning model to analyze the door transmission system predicting the operational status of subway vehicles to ensure their safe and reliable operation. The effectiveness of our method was verified based on the monitoring data of train doors on a certain subway line in Chongqing,China, and the results indicates that the constructed digital twin model has a high degree of virtual real consistency, and the Informer model based on twin data can accurately predict the operating status of car doors.

Digital Twin Smart Engineering （SE-7)



Wennian YU

Professor,
Chongqing University (China)

Title:

A digital twin-driven Wear Prediction Method of Carbon Strip for Urban Rail Vehicle Pantograph by Digital Twin

Abstract

In order to solve the problems of manual detection and low reliability of image recognition monitoring method in the wear monitoring of pantograph carbon strip for urban rail vehicle, a digital twin-driven pantograph carbon slide wear prediction method was proposed. Taking the pantograph and catenary system of Chongqing Rail Transit Line 1 as the research object, a rigid-flexible hybrid dynamic model of the vehicle-pantograph-catenary coupling system was established by Simpack, and dynamic characteristics such as dynamic contact force and friction force between the pantograph strip and catenary contact wire were accurately obtained. The Kriging method was used to construct the dynamic lightweight surrogate model, and the lightweight simulation of the dynamic characteristics of the vehicle-pantograph-catenary system was realized. According to the Archard adhesive wear calculation formula and considering the contact dynamic characteristics of the vehicle-pantograph-catenary system, the wear calculation formula of the contact pair of the pantograph strip was constructed to predict the wear thickness and wear profile of the pantograph strip. According to the actual wear data of pantograph strip collected by regular measurement, the parameter identification of pantograph strip wear prediction model was completed by using genetic algorithm. By extrapolating the wear trend, the digital twin-driven wear monitoring of pantograph carbon slide and the prediction of remaining service life of pantograph strip were realized according to the international standard documents of the wear failure threshold of the pantograph strip and the current quality assessment of the pantograph strip provided by the pantograph strip manufacturer, and theoretical guidance was provided for the replacement, maintenance and structural design of the pantograph strip in the pantograph-catenary system.

Digital Twin Smart Engineering （SE-8)



Yizhen PENG

Associate Professor.,
Chongqing University (China)

Title:

Deep Interpretable Network-Based Digital Twin Model for Pantograph-Catenary Wear Prediction

Abstract

Predicting the progression of wear in the pantograph-catenary (PC) system is essential for safeguarding the operational safety of urban rail transit. In this study, we embed the surface wear mechanism into the deep NBeats network, leveraging the principle of inductive bias to capture the underlying physics. Furthermore, we augment this approach with a graph model that encapsulates the dynamic evolution of the PC system. By integrating these components, we introduce a digital twin system grounded in a deep interpretable graph model, specifically tailored for the predictive analysis of pantograph-catenary wear. This novel framework is expected to enhance the precision and reliability of wear prediction, thereby contributing to the maintenance and longevity of urban rail infrastructure.

Digital Twin City (C)

Chair



Cecilia BOLOGNESI

Professor,
Politecnico di Milano (Italy)

Co-Chair



Qian-Cheng WANG

PhD Candidate,
University of Cambridge (UK)



Xuan LIU

Doctoral Candidate,
Eindhoven University of Technology (Netherlands)

Session on

Digital Twin City (C)

Tuesday, October 15th 2024

Tencent ID: 202-107-096
https://meeting.tencent.com/dm/JFuK5mlfi9PO

Milan Time	Beijing Time	Agenda
14:00	20:00	**C-1** Information Systems in the Built Environment: Driving Climate Action and Meaningful Transformation through AI and Data-Driven Technologies Bige TUNÇER
14:30	20:30	**C-2** Automated analysis of infrastructure policies using natural language processing (NLP) Wei-Ting HONG
15:00	21:00	**C-3** Smart Evacuation Systems Using digital twin and AI in Building Fires Yuxin ZHANG
15:30	21:30	**C-4** From urban modelling to city digital twins – Some reflections Li WAN
16:00	22:00	**C-5** Integrating Digital Twin Technology for Sustainable Urban Development: A Focus on Transit-Oriented Development Qian XU
16:30	22:30	**C-6** Data-Driven Energy Performance Analysis: Insights from London's Residential Buildings Cuicheng ZHANG
17:00	23:00	**C-7** Research for the construction of digital twins for the knowledge and maintenance of historical architectural heritage Cecilia BOLOGNESI

Digital Twin City (C-1)



Bige TUNÇER

Professor,
Eindhoven University of Technology (Netherlands)

Title:

Information Systems in the Built Environment: Driving Climate Action and Meaningful Transformation through AI and Data-Driven Technologies

Abstract

This talk explores how information systems in the built environment can drive climate action and transformative change through AI and data-driven technologies. It highlights the role of multi-source, multi-scale, and multi-time data on built environment parameters, user patterns and opinions, and sensible environmental characteristics can yield actionable insights and socio-technical solutions for big issues. The talk will present methodologies for creating intelligent design support tools, showcase case studies, and discuss the potential of data-driven strategies and AI to foster climate resilience, enhance user experience, and support decision-making for a more sustainable built environment.

Digital Twin City (C-2)



Wei-Ting HONG

Research Associate,
University of Sydney (Australia)

Title:

Automated analysis of infrastructure policies using natural language processing (NLP)

Abstract

This study presents an NLP-driven framework for analysing infrastructure policy trends over time to support policymaking. By leveraging NLP techniques, the framework identifies and classifies key infrastructure policies, offering strategic insights and flexibility for further statistical analysis. The proposed infrastructure policy strategic map categorises policies based on trends and frequency of mentions, providing an efficient tool for policymakers. A case study of New South Wales (NSW) infrastructure policymaking highlights shifts in policy priorities. This scalable framework can be applied to other jurisdictions, enabling efficient analysis of large volumes of infrastructure policy data.

Digital Twin City (C-3)



Yuxin ZHANG

Research Assistant Professor,
The Hong Kong Polytechnic University (China)

Title:

Smart Evacuation Systems Using digital twin and AI in Building Fires

Abstract

The development of real-time smart evacuation systems is vital for enhancing public safety during building fires, providing a crucial societal benefit. This study introduces an intelligent Emergency Digital Twin (EDiT) system enabling real-time tracking, speed estimation, and privacy protection of evacuees. Achieving detection success rates of 100% for individuals and 93% for multiple objects, the system significantly improves evacuation efficiency. Moreover, the creation of the Human Behaviour Detection Dataset (HBSet) enhances the ability to identify vulnerable groups, such as the elderly and disabled, ensuring they receive necessary assistance during emergencies. Additionally, a novel multi-camera tracking system is introduced, offering seamless monitoring across complex buildings. The integration of AI and digital twin technology in emergency management not only optimizes evacuation strategies but also contributes to a safer, more resilient urban environment. This advancement aids authorities in making informed, timely decisions, ultimately reducing casualties and property damage in fire scenarios, representing a critical societal safeguard.

Digital Twin City (C-4)



Li WAN

Associate Professor,
University of Cambridge (UK)

Title:

From urban modelling to city digital twins – Some reflections

Abstract

The fast advancement of digital twins (DTs) in engineering and manufacturing is now driving an economy-wide technological revolution. The success of DT applications in manufacturing demonstrates the power of data and machine learning techniques in unlocking significant performance improvements and efficiency gains. Upscaling engineering DTs to city digital twins (CDTs), however, faces several inherent challenges. DTs are most useful when the problem and solution space resemble a well-definable, closed engineering system. Unfortunately, most societal challenges do not fit this description. Existing big data sources for cities, despite unprecedented in terms of their volume and velocity, may still be 'tiny' relative to the sheer complexity of urban systems and processes. The effectiveness of a purely data-driven approach in CDT development might thus be overstated. Given the substantial knowledge gap in understanding how cities function and rising concerns about data privacy and AI ethics, it is thus questionable to assume that CDTs can and should pursue the same level of analytical and automation capability seen in engineering and manufacturing sectors. Enhancing a positive feedback loop between data and CDT models, particularly by informing data collection through theory-driven model calibration and validation, seems a promising way to advance CDT models.

Digital Twin City (C-5)



Qian XU

Lecturer (Assistant Professor),
University of Lincoln (UK)

Title:

Integrating Digital Twin Technology for Sustainable Urban Development: A Focus on Transit-Oriented Development

Abstract

The rise of Digital Twin technology offers significant potential for enhancing sustainability in urban development, particularly in the context of Transit-Oriented Development (TOD) and compact city frameworks. This presentation introduces a novel approach that integrates Digital Twin systems into the Node-Place-Ecology (NPE) model to simulate, monitor, and optimize TOD sustainability across urban environments. By creating real-time digital replicas of TOD station areas, the model facilitates a dynamic and accurate analysis of transportation, land use, and ecological factors.

Utilizing the Tokyo Metropolitan Area as a case study, this research demonstrates how Digital Twin technology enables continuous monitoring and real-time updates of urban development, enhancing the ability to address challenges such as shifting population densities, economic changes, and environmental impacts. The integration of Digital Twin allows for precise tracking of TOD performance, helping urban planners and policymakers simulate future scenarios and develop data-driven strategies to improve sustainability outcomes.

This presentation will explore how the combination of Digital Twin and the NPE model creates a comprehensive framework for managing the complexities of modern cities, ensuring long-term resilience and adaptability in the face of rapid urbanization and environmental change.

Digital Twin City (C-6)



Cuicheng ZHANG

PhD Researcher,
University of Oxford (UK)

Title:

Data-Driven Energy Performance Analysis: Insights from London's Residential Buildings

Abstract

This research leverages digital twin technology to examine the relationship between socio-demographic factors and building attributes on energy efficiency and environmental impacts in London's residential buildings from 2011 to 2021. By utilizing Energy Performance Certificates (EPCs) and socio-demographic data, it integrates complexity science and data-driven methodologies, including machine learning models like GLM and XGBoost. The study reveals that factors such as income, employment, and cultural diversity significantly affect energy efficiency. Through the digital twin framework, the research suggests digital twin oriented adaptive energy policies that account for socio-demographic changes, aiming to guide sustainable urban development and enhance environmental outcomes.

Digital Twin City (C-7)



Cecilia BOLOGNESI

Professor,
Politecnico di Milano (Italy)

Title:

Research for the construction of digital twins for the knowledge and maintenance of historical architectural heritage

Abstract

The issue of the maintenance of Italy's valuable historical built heritage often must reckon with the size of publicly owned assets or those of religious bodies. In cases such as these, the construction of management models useful for maintenance with efficient processes passes obligatorily through the digitisation of the heritage first and the construction of automatisms proper to the digital twin. In this presentation, we will touch upon three nodal points of this theme: the use of a collaborative environment for multi-user sharing of synchronically annotated information, monitoring of the influx of people with feedback in the digital model, structural monitoring and automatic quantification of materials and works for maintenance.

Digital Twin Health and Medicine（HM)

Chair



Dedong MA

Chief Physician, Professor, Doctoral supervisor

Qilu Hospital of Shandong University (China)

Co-Chair



Peppino PAFFI

Chief of the ‘Anaesthesia and Resuscitation’

P.O. San Francesco di Nuoro Hospital, of ASL Nuoro (Italy)



Gang HOU

Deputy Head of Section, Chief Physician, Doctoral supervisor

China-Japan Friendship Hospital (China)

Session on

Digital Twin Health and Medicine (HM)

Wednesday, October 16th 2024

Tencent ID: 249-162-652
https://meeting.tencent.com/dm/wtCvSssZfNgG

Milan Time	Beijing Time	Agenda
14:20	20:20	**HM-1** Artificial Intelligence and Digital Technology in Respiratory Intervention Gang HOU (Online)
14:40	20:40	**HM-2** Digital-Twin Technique Applied to Risk Disclosure Reduced Peri-bronchoscopy Anxiety: A Multi-Center, Randomized, Controlled Trial Mingming DENG (Online)
15:00	21:00	**HM-3/ML-24** Advances in Metacosmic Medicine Chunxue BAI (Onsite)
15:25	21:25	**HM-4/ML-25** To be announced Peppino PAFFI (Onsite)
15:50	21:50	**HM-5/ML-26** Inhaled Drug Efficacy Prediction Based on Digital Twin Dedong MA (Onsite)
16:15	22:15	**HM-6** GenAI Facilitated Intelligent Spine OPD Teng Grace ZHANG (Online)
16:35	22:35	**HM-7** The Digital Twin: a Potential Solution for Personalized Diagnosis and Treatment of Musculoskeletal Diseases Zhonghai LI (Online)
16:55	22:55	**HM-8** Transforming Drug Repurposing: AI-powered Digital Twins in Virtual Clinical Trials Yi-Ching HSUEH (Online)
17:20	23:20	**International Medical Digital Twin Open-Source Initiative**

Digital Twin Health and Medicine（HM-1)



Dr. Gang HOU

Deputy Head of Section, Chief Physician, Doctoral supervisor ,
China-Japan Friendship Hospital (China)

Title:

Artificial Intelligence and Digital Technology in Respiratory Intervention

Abstract

Artificial Intelligence (AI) and digital technologies are advancing rapidly, and we are now using these new technologies in respiratory interventions.

They can help us in diagnostic support, personalized treatment, monitoring and early warning, training and education, etc. These applications not only help to improve clinical outcomes, but also optimize resource allocation, promote early detection and intervention of respiratory diseases, and ultimately promote the overall improvement of healthcare services.

Digital Twin Health and Medicine（HM-2)



Dr. Mingming DENG

Assistant Researcher, postdoctoral student

China-Japan Friendship Hospital (China)

Title:

Digital-Twin Technique Applied to Risk Disclosure Reduced Peri-bronchoscopy Anxiety: A Multi-Center, Randomized, Controlled Trial

Abstract

Background: Informed consent is essential, yet providing detailed risk information often heightens preoperative anxiety in bronchoscopy patients. Conventional text-based explanations can be challenging to comprehend, highlighting the need for visual consent methods. To address this, we developed a digital-twin bronchoscopy simulator to visualize the procedure and assessed its effect on patient anxiety.

Methods: In this prospective, multicenter, randomized controlled trial, we assessed preoperative anxiety using the modified Amsterdam Preoperative Anxiety and Information Scale (APAIS) and a 100mm Anxiety Visual Analogue Scale (VAS) before and after obtaining informed consent.

Results: The study included 110 patients undergoing elective local anaesthesia for bronchoscopy. Baseline demographics were similar between the two groups. After using the personalised data-based bronchoscopy simulator, patients showed a significant reduction in anxiety as measured by APAIS (mean -5.29 vs 2.13) and VAS (mean -8.67 vs 8.47).

Conclusion: Pre-operative risk disclosure via a digital-twin based bronchoscopy simulator yielded significantly lower pre-operative anxiety than conventional risk disclosure.

Digital Twin Health and Medicine（HM-3)



Prof. Chunxue BAI

Director of Shanghai Institute of Respiratory Disease, Doctoral Supervisor, Director of Lung Tumor Comprehensive Diagnosis and Treatment Center, Zhongshan Hospital of Fudan University (China)

Title:

Advances in Metacosmic Medicine

Abstract

Metaverse medicine is a rapidly growing field that applies digital technologies such as virtual reality (VR), augmented reality (AR), and blockchain to the healthcare industry. The development of meta-universe medicine has not only brought innovations in the way healthcare services are delivered, but has also reduced healthcare costs and improved accessibility and efficiency. With the continuous advancement of technology, healthcare services in the future will be more intelligent and humanized.

Digital Twin Health and Medicine（HM-4)



Peppino PAFFI

Chief of the 'Anaesthesia and Resuscitation'
P.O. San Francesco di Nuoro Hospital, of ASL Nuoro (Italy)

Title:

To be announced

Abstract

To be announced

Digital Twin Health and Medicine（HM-5)



Prof. Dedong Ma

Chief Physician, Professor, Doctoral supervisor
Qilu Hospital of Shandong University (China)

Title:

Inhaled Drug Efficacy Prediction Based on Digital Twin

Abstract

With the continuous development of medical technology, inhaled medications have become an important means of treating respiratory diseases. A digital twin is a virtual copy of a physical entity or system in digital space, which realizes a true reflection of the real world state through real-time data acquisition and analysis. In the context of inhalation drug efficacy prediction, digital twins can help us simulate the behavior of drugs in the body and thus predict drug efficacy.

Digital Twin Health and Medicine（HM-6)



Dr. Teng Grace ZHANG

Assistant Professor, Director of the Digital Health Laboratory,
The University of Hong Kong (China)

Title:

GenAI Facilitated Intelligent Spine OPD

Abstract

With the rapid development of Artificial Intelligence (AI) technology, Generative Artificial Intelligence (GenAI) has shown great potential in healthcare, especially in Intelligent Spine Outpatient Departments (OPDs). GenAI is used to generate and analyze large amounts of medical data, including imaging data, medical records and patient feedback, and extract valuable information through algorithmic models. It can help doctors quickly diagnose spine-related diseases and also provide personalized treatment recommendations.

Digital Twin Health and Medicine（HM-7)



Dr. Zhonghai LI

Chief Physician, Associate Professor, Postdoctoral Fellow
The First Hospital of Dalian Medical University (China)

Title:

The Digital Twin: a Potential Solution for Personalized Diagnosis and Treatment of Musculoskeletal Diseases

Abstract

Digital twin technology offers a potential solution for personalized diagnosis and treatment of musculoskeletal disorders. By creating a digital twin model of a patient, physicians are able to gain a more comprehensive understanding of the patient's physical condition and complex pathology. This technology utilizes advanced sensors and data analytics to collect and monitor a patient's physiological data in real time, which in turn allows for a customized treatment plan for each patient. The digital twin not only improves the early detection of disease, but also optimizes treatment outcomes, helping to achieve more accurate and efficient healthcare and ultimately improving patients' quality of life.

Digital Twin Health and Medicine（HM-8)



Dr. Yi-Ching HSUEH

Clinical Research and Development Director ,
Phil Rivers Technology Co., Ltd (China)

Title:

Transforming Drug Repurposing: AI-powered Digital Twins in Virtual Clinical Trials

Abstract

Artificial intelligence digital twins are revolutionizing the vast landscape of drug discovery and development, especially in virtual clinical trials. This innovative technology dramatically accelerates the search for drug repurposing by accurately simulating patient physiology and drug response. Instead of waiting for lengthy physical trials, digital twins can predict new drug efficacy in a virtual environment, opening up efficient pathways for marketed drugs to explore new therapeutic areas. This not only reduces R&D costs, but also brings potential therapeutic solutions to patients more quickly, opening up a new era of drug development.

Digital Twin Health and Medicine (HM)



International Medical Digital Twin Open-Source Initiative

In recent years, digital twin technology has been applied in the medical field, including disease prediction and prevention, precision medicine, surgical planning and optimization, medical equipment management, and optimal allocation of medical resources. This initiative is proposed to revolutionize global healthcare through an open-source platform that promotes international collaboration and technology sharing focused on the development of advanced medical digital twin technology.

Members of the global healthcare community are invited to contribute your expertise to the open-source platform development, participate in research projects and workshops, and share your knowledge and experience with the global medical community. By working together, we can create a more accessible, equitable, and innovative future for healthcare through advanced medical digital twin technology.

Initiators: Fei Tao, Chunxue Bai, Dedong Ma, Gang Hou, Tianliang Hu

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Digital Twin Logistics （L）

Chair



Ning Zhao

Professor

University of Science and Technology Beijing (China)

Co-Chair



Ting Qu

Professor

Jinan University (China)



Wenfeng Li

Professor

Wuhan University Of Technology (China)



Haobin Li

Senior Lecturer

National University of Singapore (Singapore)



Jianbin Xin

Associate Professor

Zhengzhou University (China)

Session on

Digital Twin Logistics (L)

Wednesday, October 16th 2024

Tencent ID: 734-244-443
https://meeting.tencent.com/dm/hTDnINQfyN1W

Milan Time	Beijing Time	Agenda
15:00	21:00	**L-1** Rethinking Freight: Unlocking the Potential of Digital Twins for a Greener Transport Mahnam SAEEDNIA
15:30	21:30	**L-2** Enhancing Container Terminal Operations Through a Four-Dimensional Digital Twin Framework Mengya LIU
16:00	22:00	**L-3** Rethinking Freight: Unlocking the Potential of Digital Twins for a Greener Transport Ning ZHAO
16:30	22:30	**L-4** Digital twin-driven proactive-reactive scheduling framework for port multi-equipment under a complex uncertain environment Lei CAI
17:00	23:00	**L-5** A Bottleneck Dynamic Detection and Workload Control Method for Synchronized Production System Based on Digital Twin Workload Space Lin MA
17:30	23:30	**L-6** Centralized scheduling approach based on digital twin for robotic scheduling in robotic mobile fulfillment systems Yangjun SUN

Digital Twin Logistics （L-1）



Mahnam SAEEDNIA

Assistant Professor
Delft University of Technology (The Netherlands)

Title:

Rethinking Freight: Unlocking the Potential of Digital Twins for a Greener Transport

Abstract

As freight transport industry is under pressure to reduce emissions towards net-zero, digitalization becomes not just a powerful tool, but an essential enabler. The digital transformation is gaining momentum and is increasingly critical in the face of climate change and extreme events. Although Digital Twins have yet to see widespread adoption in the logistic sector, many foundational technologies are already in place. These include advanced tracking and tracing systems, open API strategies, and the shift to cloud-based IT infrastructures. Additionally, progress in machine learning and advanced analytics is enabling optimization of supply chains and providing new insights from historical shipment and operational data. Logistic professionals are also leveraging augmented, mixed, and virtual reality applications for tasks like warehouse picking and vehicle loading. The data generated from these activities is particularly well-suited for the creation of Digital Twins in these environments. As a result, the industry is presented with unique opportunities to accelerate the use of Digital Twins across the sector. The ongoing exploration of potential use cases for Digital Twins in logistics is crucial for preparing the sector for full-scale implementation in the coming years. As other industries begin to embrace this technology, it is essential for the logistics sector to position itself within a broader context of digital transformation and innovation.

Digital Twin Logistics （L-2)



Mengya LIU

Research Fellow

National University of Singapore (Singapore)

Title:

Enhancing Container Terminal Operations Through a Four-Dimensional Digital Twin Framework

Abstract

Digital Twins have advanced into a key technology for enabling real-time decision-making and optimizing operations, especially in the highly complex context of mega container terminals. A Digital Twin framework of four dimensions — Connectivity, Visibility, Fidelity, and Analyzability —can be implemented and tailored to meet the unique demands of these terminals: Seamless data integration, intuitive visualization of terminal processes, precise modelling, and advanced analytical capabilities provide operators with critical insights into container movements, resource allocation, and bottleneck identification. This framework not only improves operational efficiency but also enhances the ability to predict and optimize performance in a dynamic logistics landscape. The progressive development of this system offers a roadmap for advancing global logistics through smarter and more responsive terminal operations.

Digital Twin Logistics （L-3)



Ning ZHAO

Assistant Professor , FHEA, CEng, IMechE, PhD

University of Birmingham (UK)

Title:

The implementation of Train Intelligent Driving Strategy with Digital Twin

Abstract

Rail systems consume a considerable amount of energy in day-to-day operations. Due to increasing environmental concerns, rail operators are under growing pressure to conserve energy. An effective strategy for controlling driving can significantly impact energy-saving performance.

At BCRRE, we collaborated with Ricardo to develop an intelligent driving strategy solution, initially sponsored by UK Tram. This technology aims to provide enhanced control strategies for drivers to achieve energy-efficient operation. By implementing digital twin technology, our team modelled the route and identified the optimal driving strategy for individual route sections.

"We aim to improve drivers, rather than replace them with machines."

This solution has been successfully implemented by Edinburgh Trams since 2019, resulting in significant energy savings. Edinburgh Trams was even awarded a Highly Commended recognition in the Best Environmental and Sustainability Initiative category at the Global Light Rail Awards.

Digital Twin Logistics （L-4）



Lei CAI

PhD student,
Wuhan University of Technology (China)

Title:

Digital twin-driven proactive-reactive scheduling framework for port multi-equipment under a complex uncertain environment

Abstract

The pervasive uncertainties in multiple port equipment scheduling frequently result in container handling delays or ineffective plans. To address the complexities and uncertainties of port multiple equipment integrated scheduling problem, this presentation introduces a Digital Twin-driven (DT-driven) proactive-reactive scheduling framework. This framework is designed to promptly respond to uncertainties in the scheduling process and provide a transparent visualization of operational information. By developing a virtual container port simulation, which features a U-shaped port layout and double-cycling mode drawn from real-world scenarios, the presentation evaluates the proposed framework’ s effectiveness. The experimental results demonstrate that the DT-driven framework significantly improves efficiency and conserves energy. Additionally, in large-scale conditions, the makespan difference between the DT-driven approach and the non-DT-driven approach is as much as 19.56 %. In terms of energy consumption savings, the DT-driven approach’ s scheduling plan can save 3.67 % of energy consumption under large-scale conditions. Moreover, as the disturbance degree increases, the energy consumption savings become even more significant.

Digital Twin Logistics （L-5）



Lin MA

Postdoctoral Research Fellow
Jinan University Zhuhai Campus (JNU) (China)

Title:

A Bottleneck Dynamic Detection and Workload Control Method for Synchronized Production System Based on Digital Twin Workload Space

Abstract

The client demands exhibit high uncertainty in Industry 4.0, which poses challenges for the Production Planning and Control (PPC) in Multi-Cellular Synchronized Production System (MCSPS). Conventional reactive PPC solutions often result in imbalanced workloads across the units due to insufficient overall capacity. In response, we shift our insights from “real-time capacity assessment for deterministic demands” to “timely workload space reservation for uncertain demands”, and introduce a digital twin-based workload space to balance the real-time operational states, including actual workload, adaptive equilibrium, and ideal equilibrium. This research emphasizes throughput bottleneck detection through real-state mapping, optimization of workload balancing via global decision-making, and probability-based methods to achieve balance in the ideal state. Additionally, the control structure evolves from single-level to cascade control. The outcomes will be tested using a laboratory physical factory model.

Digital Twin Logistics （L-6)



Yangjun SUN

Post-Doctoral Researcher,
University of Science and Technology Beijing (China)

Title:

Centralized scheduling approach based on digital twin for robotic scheduling in robotic mobile fulfillment systems

Abstract

The Robotic Mobile Fulfillment System (RMFS) is a "goods-to-worker" system that utilizes pods to store goods and employs robots for pods movement. Due to the common problems of "many conflicts, chain conflicts, and frequent deadlock" in a large number of mobile robots operation, the system is inefficient, and even regional downtime. To solve this problem, a centralized scheduling approach based on digital twin for robotic scheduling was proposed. A digital twin model with physical system, virtual system, twin data center, and support services for system operation was established. Instruction acceptance and data acquisition mechanism for physical system, scheme generation and simulation mechanism for virtual system, and data processing and comparison mechanism for twin data center are established. Support services for system operation is used to ensure the smooth operation of the three mechanisms. Conflict prediction is achieved through a digital twin system to obtain an optimized conflict-free scheduling scheme when the robot is not yet operational. Through the data interaction between physical system and virtual system, real-time scheduling is ensured when orders continue to arrive. According to different disturbances in RMFS, the rescheduling rules are determined to generate new schemes. Through cases, the research and application scenarios of the above methods in the future are illustrated.

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