Session on

Digital Twin Smart Engineering (SE)

Tuesday, October 15th 2024

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Milan Time	Beijing Time	Agendas
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）

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)

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

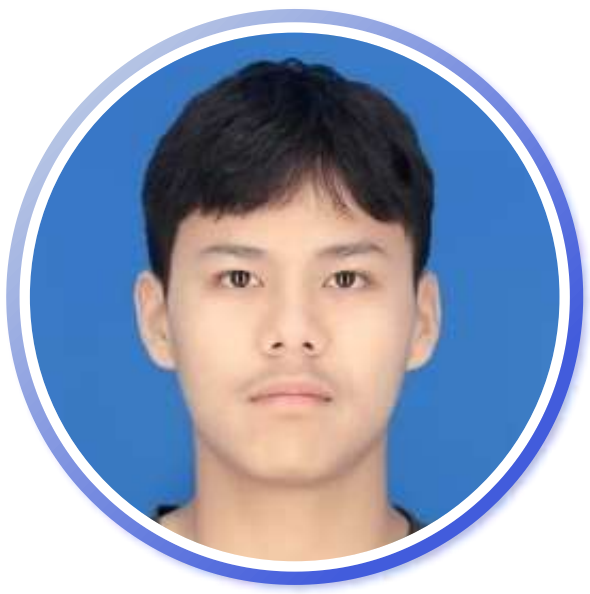
Master Student,
Albstadt-Sigmaringen University (Germany)

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.