Xi'an Jiaotong-Liverpool University 西交利物浦大学

智能工程学院 SCHOOL OF ADVANCED TECHNOLOGY

SAT 2025 Mini-wrkshop Series

Key Design Aspects in Digital Twins: Systems, Modeling, and Resource Optimization

Host:

Dr. Jie Zhang | Associate Professor, Department of Communications and Networking | SAT

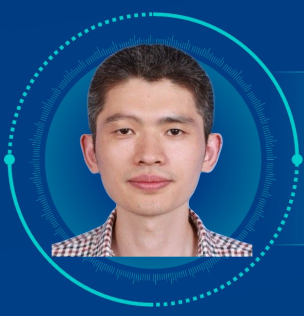
Aganda

13: 30-14: 00

Registration

14: 00-14: 30

Parallel Systems Based on Cyber-Physical-Social-System



Dr. Fenghua Zhu

Associate Professor

Institute of Automation Chinese Academy of Sciences

14: 30-15: 00

Collaborative Optimization Method for Network-Computation-Control under Delay Interference

Dr. Yuqi Liu

Assistant Researcher

Shenyang Institute of Automation Chinese Academy of Sciences

15: 00-15: 10

Break

15: 10-15: 30

Knowledge-informed Deep Learning for Traffic Modelling and Prediction

Dr. Dongyao Jia

Associate Professor

Department of Communications and Networking SAT | XJTLU

15: 30-15: 50

DRL-Enabled Communication and Computation Resource Management for UAV-Aided IoT

Dr.Yuan Jian

Assistant Professor

Department of Communications and Networking SAT | XJTLU

15: 50-16: 30

Discussion

DATE Friday, June 27

Venue EB415

Language Chinese (IFlytek translation provided)

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Abstract

Parallel Systems Based on Cyber-Physical-Social-System (CPSS)

Focusing on the complexity of smart cities, applying complex systems research to address modeling, experimentation, optimization, and evaluation challenges in urban management is becoming a key future trend. Social Cyber-Physical Systems (CPSS) represent a new class of complex systems that integrate physical infrastructure, human and social elements, and the cyber systems that connect them.

Building on CPSS, the concept of parallel systems aims to tackle the modeling difficulties of real-world systems by combining theoretical, empirical, and data-driven approaches to construct artificial systems that are functionally equivalent to real ones. These artificial systems enable computational experiments to explore how various elements interact and evolve under both normal and abnormal conditions. By comparing real and artificial systems, we can analyze behavior, forecast trends, and improve decision-making through refined control and management strategies.

Coordinated Optimization Methods for Network-Computing-Control under Delay Interference

In modern networked control systems, the tight coupling among control, computing, and network scheduling poses challenges, especially under network delays and limited resources. Traditional independent design methods struggle to meet real-time and stability demands.

This report presents a coordinated optimization approach for network-computing-control under delay interference. By leveraging reinforcement learning and self-triggered mechanisms, it enables joint design of control, task scheduling, and resource allocation. The method improves dynamic response, reduces overhead, and shows strong potential for intelligent edge control systems.

Knowledge-informed Deep Learning for Traffic Modelling and Prediction

Traffic digital twins require accurate, adaptable models to reflect complex, real-world dynamics. This presentation introduces a unified knowledge-informed deep learning (KIDL) framework that overcomes the limitations of traditional data-driven methods by integrating Large Language Models (LLMs) with domain-specific designs.

KIDL enhances two key tasks:

1. Car-following behavior modeling: LLM knowledge distillation improves vehicle interaction stability and generalization.
2. Lane-level traffic forecasting: LLM-generated synthetic data boosts modeling of dynamic spatial patterns in unseen conditions.

The approach improves prediction accuracy, reduces computational costs, and adapts well to limited data—key for scalable, high-resolution digital twins. Real-world experiments show KIDL outperforms state-of-the-art methods in both generalizability and stability, highlighting its promise for future traffic simulation and management.

DRL-Enabled Communication and Computation Resource Management for UAV-Aided IoT

Wireless communication is a cornerstone of modern industry and daily life, with key applications including Starlink, cellular networks, and IoT services like smart homes, telesurgery, and autonomous driving. As AI technologies—especially machine learning—advance, future wireless systems are expected to be AI-native.
A critical enabler will be the space-air-ground integrated network (SAGIN), offering seamless, global connectivity. Within SAGIN, UAV-assisted non-terrestrial networks (NTN) provide adaptability and resilience through flexible deployment and mobility.

This talk presents deep reinforcement learning (DRL)-based solutions for:

1. Intelligent path planning of cellular-connected UAVs
2. Energy efficiency optimization in multi-UAV-assisted MEC systems for IoT

These DRL-driven approaches tackle the complex decision-making challenges of next-generation UAV-enabled communication and computing, paving the way for scalable, intelligent, and dynamic network infrastructures.