專 題 演 講

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題 目： Challenges of Digital Twin Learning for Deep Learning Based Intelligent Robotics

大 綱：

Collecting data on a large scale is vital for the development of cutting-edge artificial intelligence (AI) technologies, especially those involving machine learning (ML) models, such as deep neural networks, which require training with relevant data. On one hand, the collection of real-world data, using devices such as cameras and microphones, would enable AI systems to better understand everyday life and ultimately behave or assist in a manner akin to human interaction. On the other hand, growing concerns about security and privacy make it increasingly difficult to collect such real-world data. As a result, the emergence of digital twins offers a promising direction for intelligent robots that employ deep learning models for tasks such as perception, planning, localization, and control.

This presentation will discuss a framework for data collection, training, and learning, utilizing the assistance of digital twins. This approach leverages a collection of AI models for self-navigating mobile robots. We will focus particularly on developing visual perception models that interpret the real world through a camera. These models play a pivotal role in a variety of AI-powered products and services, such as autonomous vehicles and smart cities. They are also a primary research focus at Elsa Lab. Visual perception models based on deep neural networks have achieved unprecedented accuracy in benchmark datasets. Implementing these models would enable edge AI systems to better perceive and understand their environments, and therefore acting more intelligently in the real world. However, they often experience drops in accuracy and lack sufficient effective real-world data samples. This can lead to unsatisfactory performance and safety concerns in practical deployments.

To address the aforementioned problems, we explore and incorporate the following key technologies into our framework: virtual-to-real transfer learning, foundation model-based domain adaptation, and the usage of mid- level representations. Virtual-to-real transfer learning enables ML models to train first in simulated environments and then migrate to real-world settings with ease. Foundation model-based domain adaptation facilitates this migration process, even under challenging scenarios where data collection in the real world involves labor-intensive manual preprocessing. Moreover, mid-level representations are employed to transmit various types of information from the perception module to the control module, forming the basis of modular frameworks in many learning-based systems. The primary scientific challenge of this research direction lies in integrating these elements into a unified solution, and improving the adaptation ability of AI models to real- world environments. We will present how these methodologies can be integrated with existing systems for intelligent perception, planning, localization, and control in deep learning-based intelligent robotics.

簡 歷:

Chun-Yi Lee is a Professor of Computer Science at Na7onal Tsing Hua University (NTHU), Hsinchu, Taiwan and the supervisor of Elsa Lab. He received his B.S. and M.S. degrees from Na7onal Taiwan University, Taipei, Taiwan, in 2003 and 2005, respec7vely, and the M.A. and Ph.D. degrees from **Princeton University**, Princeton, NJ, USA, in 2009 and 2013, respec7vely, all in Electrical Engineering. Prof. Lee joined the Department of Computer Science at NTHU as an Assistant Professor in 2015. He was promoted to Associate Professor in 2019 and to full Professor in 2023. Before his tenure at NTHU, he was a senior engineer at Oracle America, Inc. in Santa Clara, CA, USA, from 2012 to 2015. Prof. Lee founded Elsa Lab at Na7onal Tsing Hua University in 2015. Under his leadership, Elsa Lab has garnered several pres7gious awards from global robo7cs and AI challenges. These include the first place at the NVIDIA Embedded Intelligent Robo7cs Challenge in 2016, first place at the NVIDIA Jetson Robo7cs Challenge in 2018, second place in the Person- In-Context (PIC) Challenge at ECCV 2018, second place in the NVIDIA AI at the Edge Challenge in 2020, and the Best Solu7on Award (1st Place) in the Small Object Detec7on Challenge for Spo[ng Birds at MVA 2023.

Prof. Lee's research is primarily in deep reinforcement learning (DRL), intelligent robo7cs, computer vision (CV), and parallel compu7ng systems. His contribu7ons include developing key deep learning methodologies for intelligent robo7cs. These include sim-to-real and real-to-sim training, transferring techniques for robo7c policies, digital twins, scene coordinate regression approaches, and domain adapta7on techniques for seman7c segmenta7on models. He has also advanced explora7on approaches for DRL agents, mul7-agent reinforcement learning (MARL) techniques, and genera7ve modeling methodologies, including super-resolu7on and score-based genera7ve models, as well as autonomous naviga7on strategies. His work has been published at major ar7ficial intelligence (AI) conferences such as NeurIPS, CVPR, IJCAI, AAMAS, ICLR, ICML, ECCV, BMVC, CoRL, ICRA, IROS, GTC, MVA, and others. In addi7on, his research appears in top AI journals, including IEEE Transac7ons on Pa`ern Recogni7on and Machine Intelligence (TPAMI), IEEE Transac7ons on Neural Networks and Learning Systems (TNNLS), Journal of Machine Learning Research (JMLR), and ACM Transac7ons on Evolu7onary Learning and Op7miza7on (TELO). In the realm of parallel system, Prof. Lee has introduced innova7ve graphics processing unit (GPU) enhancement methodologies to improve efficiency. His work in this area has been published in IEEE Transac7ons on Very Large Scale Integra7on Systems (TVLSI), IEEE Transac7ons on Computer-Aided Design of Integrated Circuits and Systems (TCAD), the Design Automa7on Conference (DAC), the Asia and South Pacific Design Automa7on Conference (ASP-DAC), and Interna7onal Conference on Computer Design (ICCD).

Prof. Lee's researches are especially impaccul in autonomous systems, decision-making systems, game engines, and vision-AI based robo7c applica7ons. Prof. Lee received the Academia Sinica Early-Career Inves7gator Research Achievement Award in 2022 and the Ta-You Wu Memorial Award from the Ministry of Science and Technology (MOST) in 2020. These are the most pres7gious awards in Taiwan recognizing outstanding achievements in intelligence compu7ng for young researchers. He has also been honored with several outstanding research awards, dis7nguished teaching awards, innova7on teaching awards, young scholar research awards, and contribu7on awards from ins7tu7ons such as NVIDIA Deep Learning Ins7tute (DLI), The Taiwan IC Design Society (TICD), The Founda7on for the Advancement of Outstanding Scholarship (FAOS), The Chinese Ins7tute of Electrical Engineering (CIEE), Taiwan Semiconductor Industry Associa7on (TSIA), Ins7tute of Informa7on & Compu7ng Machinery (IICM), and Na7onal Tsing Hua University (NTHU). Furthermore, he has served as area chair at NeurIPS 2023 and ICLR 2024, and as tutorial chair of the 18th Interna7onal Conference on Machine Vision Applica7ons (MVA 2023). He has also been commi`ee members and reviewers at many interna7onal and domes7c conferences. He has served mul7ple 7mes as session chairs and on the technical program commi`ee at IROS, ASP-DAC, NoCs, ISVLSI, and MVA, and has held various chair roles at many different interna7onal conferences. He has also served as the paper reviewers for NeurIPS, ICML, CVPR, ICLR, AAAI, ICCV, BMVC, ICRA, IROS, IEEE TPAMI, IEEE TVLSI, IEEE TCAD, IEEE ISSCC, and IEEE ASP-DAC mul7ple 7mes. Prof. Lee has been the main organizer of the 3rd, 4th, and 5th Augmented Intelligence and Interac7on (AII) Workshops from 2019 to 2023, and was the chair of the ACML Workshop on Machine Learning for Mobile Robot Vision and Control (MRVC) in 2021. He served as the co- director of the MOST Office for Interna7onal AI Research Collabora7on from 2018 to 2020. Prof. Lee is a professional member of IEEE and ACM.