YOUNG SCIENTIST AWARD 2024

Li Qianxiao
Presidential Young Professor
Department of Mathematics
National University of Singapore

"For his innovative work on the mathematical foundations of deep learning, its connections with dynamical systems, and applications in AI for science."

Dr Li Qianxiao has made significant contributions to the development of mathematical foundations of deep learning, a crucial technology that underpins the success and scalability of modern AI systems. His work has provided rigorous mathematical frameworks necessary for understanding and improving deep learning methodologies, laying the groundwork for future innovations in the field.

Together with his team, Dr Li pioneered the understanding of how expressiveness – the ability to learn arbitrary relationships – arises in deep neural networks. The team's work revealed intricate connections between this modern technology and classical mathematics, including dynamical systems theory and control theory. This has not only improved our understanding of how and when deep learning works, but also how to systematically improve its performance in new application settings. For example, Dr Li's research has led to faster ways of training low-precision neural networks, effective methods to improve adversarial robustness, and efficient approaches for fine-tuning large language and vision models.

In addition, through his joint appointment with the Institute for Functional Intelligent Materials at NUS, Dr Li's research, which is at the intersection of deep learning and dynamical systems, has found new applications in AI for science, particularly those that involve dynamical processes. For example, he developed a general methodology to learn intuitive descriptions of physical processes directly from observations of complex trajectories. This methodology has been applied to study complicated physical phenomena, such as the convection dynamics of fluids and the stretching dynamics of polymers.

Dr Li's work is highly interdisciplinary, and he has published in leading journals in mathematics (JEMS, SIAM journals), computer science (ICML, ICLR, CVPR) and the sciences (Nature Computational Science, Nature Reviews Materials, PNAS, Matter). He has been invited to deliver plenary talks in international conferences spanning applied mathematics (SciCADE 2024), machine learning (MSML 2021, CSML 2024) and the physical sciences (WINQ program at Nordita 2024). Dr Li is also the recipient of the Singapore National Research Foundation Fellowship in 2021.

Dr Li actively contributes to the local academic community. He delivered the annual Singapore Mathematical Society (SMS) lecture in 2024, served as a judge for the SMS essay competition in 2024 and as the chief setter for the Singapore International Mathematical and Computational Challenge in 2022. Furthermore, Dr Li mentors students and post-doctoral researchers with dedication, and his efforts have been recognised by NUS Faculty of Science's Faculty Teaching Excellence Award in 2021.