香 港 大 學
THE UNIVERSITY OF HONG KONG

Institute of Mathematical Research
Department of Mathematics

Frontiers of Mathematics Lecture

Machine Learning algorithms inspired by Complex Analysis, Dynamics and Whitney Embedding Theorem

Abstract

At its core, AI and machine learning algorithms represent our mathematical communication with computers. Current algorithms are the product of iterative trial and error. In our work, we propose novel machine learning algorithms derived from complex analysis. Testing results indicate that these algorithms are highly efficient in solving both mathematical and physical problems, surpassing existing Physical Informed Neural Networks (PINNs) used for solving Partial Differential Equations (PDEs) and other scientific computations, achieving improvements in both speed and accuracy—often by several orders of magnitude. Our algorithms also show strong performance in tasks like image recognition and other AI applications.

Currently, we have a team of 10 software engineers, generously donated by a private company, with a hub of 72 GPUs provided by another company in Silicon Valley, who will be testing our algorithms on Transformers and Large Language Models (LLMs) over the next three months. Initial results are promising. For example, on one task with MiniMind large language model, our algorithm, with only 0.1 billion (0.1B) parameters, achieves results comparable to the current model with 8 billion (8B) parameters—an efficiency improvement of nearly 80 times. However, it remains uncertain whether our algorithm can scale further. To put this in perspective, ChatGPT-4 operates with 8 models, each containing over 200 billion parameters.

To understand the essence of AI, we pose a simple question: Given a Sun-Earth-Jupiter three-body system, where we observe the position of Jupiter from Earth every night, and assume we know nothing about Newtonian mechanics, calculus, or universal gravitation, can a machine predict the future motion of Jupiter? The surprising answer is yes—provided there is enough data.

More generally, for any dynamical system on a manifold, enough sequential data from a single, generic observable can fully recover the original system. This result is based on the Whitney Embedding Theorem. I will also demonstrate an algorithm to implement this process.

Professor Zhihong Xia

Northwestern University

Date :
March 27, 2025 (Thursday)

Time :
5:00 – 6:00 pm
(Tea Reception starts at 4:30 pm)

Venue :
P3, Chong Yuet Ming Physics Building
The University of Hong Kong

Biography

Zhihong Jeff Xia is the Arthur and Gladys Pancoe Professor of Mathematics at Northwestern University, as well as a Chair Professor at Great Bay University. He earned his Ph.D. in Mathematics from Northwestern University in 1988. Professor Xia is renowned for solving the century-old Painlevé Conjecture and, in collaboration with Jian Li, for discovering compelling evidence that a rogue planet once invaded our solar system a few hundred million years ago. His outstanding contributions have been recognized with several prestigious awards, including the Sloan Research Fellowship, the US National Young Investigator Award, the Blumenthal Award for the Advancement of Pure Mathematics, and the Monroe Martin Prize for Applied Mathematics.

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