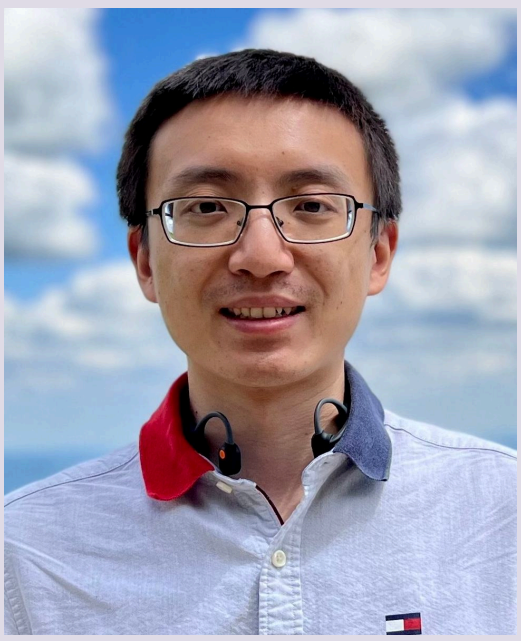
PDE-Controller: LLMs for Autoformalization and Reasoning of PDEs

BIOGRAPHY



Dr. Wuyang Chen is a tenure-track Assistant Professor in Computing Science at Simon Fraser University. Previously, he was a postdoctoral researcher in Statistics at the University of California, Berkeley. He obtained his Ph.D. in Electrical and Computer Engineering from the University of Texas at Austin in 2023. Dr. Chen's research focuses on scientific machine learning, theoretical understanding of deep networks, and related applications in foundation models, computer vision, and AutoML. He also works on domain adaptation/ generalization and self-supervised learning. Dr. Chen has published papers at CVPR, ECCV, ICLR, ICML, NeurIPS, and other top conferences. Dr. Chen's research has been recognized by NSF (National Science Foundation) newsletter in 2022, INNS Doctoral Dissertation Award and the iSchools Doctoral Dissertation Award in 2024, and AAAI New Faculty Highlights in 2025. Dr. Chen is the host of the Foundation Models for Science workshop at NeurIPS 2024 and co-organized the 4th and 5th versions of the UG2+ workshop and challenge at CVPR in 2021 and 2022.

ABSTRACT

While recent AI-for-math has made strides in pure mathematics, areas of applied mathematics, particularly PDEs, remain underexplored despite their significant real-world applications. We present PDE-Controller, a framework that enables large language models (LLMs) to control systems governed by partial differential equations (PDEs). Our approach enables LLMs to transform informal natural language instructions into formal specifications, and then execute reasoning and planning steps to improve the utility of PDE control. We build a holistic solution comprising datasets (both human-written cases and 2 million synthetic samples), math-reasoning models, and novel evaluation metrics, all of which require significant effort. Our PDE-Controller significantly outperforms prompting the latest open-source and GPT models in reasoning, autoformalization, and program synthesis, achieving up to a 62% improvement in utility gain for PDE control. By bridging the gap between language generation and PDE systems, we demonstrate the potential of LLMs in addressing complex scientific and engineering challenges.