Quantum Machine Learning

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Quantum computing and machine learning (the core of contemporary artificial intelligence) are emerging and promising technologies that would have a major impact on human life and society in the future. It is interesting to explore the interaction between quantum computing and machine learning, and study how to use the results and technologies of one field to solve problems in another field. In this talk, I will first give a brief introduction to machine learning and quantum computing. Current noisy intermediate scale quantum (NISQ) machines, without error correction implemented, are not suitable for deep quantum circuit architectures. Therefore, I will focus on algorithms and applications that can be implemented in the current and near-term NISQ machines. The variational quantum circuits with tunable parameters optimized in an iterative manner by a classical computer is a hybrid quantum-classical approach which leverages the strengths of quantum and classical computation, suitable for NISQ machines. I will present the results obtained for some machine learning tasks using variational quantum circuits.

After that I will introduce the quantum-train (QT) framework, a novel approach that integrates quantum computing with classical machine learning algorithms to address significant challenges in data encoding, model compression, and inference hardware requirements. Even with a slight decrease in accuracy, QT achieves remarkable results by employing a quantum neural network alongside a classical mapping model, which significantly reduces the parameter count from M to O(polylog(M)) during training. Our experiments demonstrate QT's effectiveness in classification tasks, offering insights into its potential to revolutionize machine learning by leveraging quantum computational advantages. This approach not only improves model efficiency but also reduces generalization errors, showcasing QT's potential across various machine learning applications.

Brief Bio:

Professor Hsi-Sheng Goan（管希聖） received his Ph.D. degree in physics from the University of Maryland, College Park, USA, in 1999. He then worked as a Postdoctoral Research Fellow at the University of Queensland, Brisbane, Australia, from 1999 to 2001. From 2002 to 2004, he was a Senior Research Fellow awarded the Hewlett-Packard Fellowship at the Center for Quantum Computer Technology, University of New South Wales, Sydney, Australia, before he took up a faculty position at the Department of Physics, National Taiwan University (NTU) in 2005. He has been a Professor of Physics at NTU since 2011 working in the fields of Quantum Computing and Quantum Information, Quantum Control, Open Quantum Systems, Mesoscopic (Nano) Physics,

Quantum Optics, and Quantum Optomechanical and Electromechanical Systems. He is currently the Director of the Center for Quantum Science and Engineering at NTU, and the Director of the IBM Quantum Hub at NTU. He has been an author and co-author of more than 100 research papers and 5 chapters in monographs or books, and has delivered more than 60 invited talks/lectures at international conferences, workshops, meetings and schools. He has served as a member of the Editorial Boards of several international scientific journals, such as EPJ: Quantum Technology, International Journal of Quantum Information, and Chinese Journal of Physics.

管希聖教授（Hsi-Sheng Goan）於 1999 年獲得美國馬里蘭大學學院市分校物理學博士學位。隨後，他於 1999 年至 2001 年間在澳洲布里斯本昆士蘭大學擔任博士後研究員。從 2002 年至 2004 年，他獲得惠普獎學金（Hewlett-Packard Fellowship），並於澳洲悉尼新南威爾士大學量子計算技術中心擔任高級研究員。2005 年，他加入國立臺灣大學物理學系，擔任教職。自 2011 年起，他在臺大擔任物理學教授，研究領域包括量子計算與量子資訊、量子控制、開放量子系統、介觀（奈米）物理、量子光學以及量子光力學與電機械系統。

目前，管教授是國立臺灣大學量子科學與工程中心的主任，同時兼任臺大 IBM Quantum Hub 的主任。他已發表超過 100 篇研究論文及 5 個專著或書籍章節，並在國際會議、工作坊、學術會議與學校中發表過超過 60 場邀請演講。他曾擔任多個國際科學期刊的編委會成員，如《EPJ: Quantum Technology》、《International Journal of Quantum Information》和《Chinese Journal of Physics》。