LECTURES ON FRONTIERS OF QUANTUM MATTERS

量子物质前沿讲座

清華大學 Tsinghua University

TITLE |

Machine Learning Holography

SPEAKER |

Yi-Zhuang You (University of California, San Diego)

TIME |
2:00-3:30 June 4, 5, 6, 2019

VENUE |
Room 322, Science Building
Tsinghua University

主办方：清华大学高等研究院

ABSTRACT

Lecture I: from Tensor Network to Boltzmann Machine

I will discuss the paper arXiv:1709.01223 on entanglement feature learning. I will start with the definition of entanglement features and demonstrate the calculation on random tensor networks. The result turns out to be a holographic Ising model, which is closely related to a deep learning architecture: the deep Boltzmann machine. I will review the idea of Boltzmann machine and discuss the challenge and strategy in training a deep Boltzmann machine. I will apply the machine learning approach to uncover the holographic spatial geometry emergent from entanglement features of quantum many-body states. Finally, I will briefly mention the on-going research of applying machine learning to study quantum information dynamics.

Lecture II. from Renormalization Group to Generative Model

I will discuss the paper arXiv:1903.00804 on neural network renormalization group. I will start with an overview of the close relations among the renormalization group, holographic mapping, and deep learning. In particular, I will review the exact holographic mapping on free fermion systems, which establishes a profound relation between renormalization group with holographic mapping. Then I will introduce the neural network renormalization group approach, which is a flow-based deep generative model aiming to generate field configurations of a quantum field theory. This approach enables artificial intelligence to replace human physicists in designing renormalization group schemes. Applying this approach, I will demonstrate the generalization of the exact holographic mapping to interaction boson systems, which reveals the close analogy between holographic duality and deep generative models. The method may find useful applications in the study of critical systems.

Lecture III. from AdS/CFT to Neural ODE

I will discuss the paper arXiv:1802.08313 on deep learning AdS/CFT. I will start with an introduction of AdS/CFT duality, using the example of the scalar phi^4 model in the holographic bulk. I will explain how recurrent neural networks can model the equation of motion for the bulk field, which provides data-driven holographic modeling of strongly coupled quantum systems and enables us to apply the deep learning algorithms to learn the holographic bulk geometry form the data of response function. I will continue to discuss the on-going research effort on replacing the recurrent neural network by neural ODE, and reformulate the training task as a generative model. In the end, I will envision a few future directions of machine learning holography to incorporate gauge and gravitational fluctuations.