From Vector Data to Quantum Circuits: TTNOpt for Efficient Tensor-Network Encoding

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Recent progress in quantum hardware has increased the importance of methods that explicitly convert classical vector data into quantum circuits through tensor-network (TN) representations. Once an isometric TN is obtained, scalable quantum state preparation becomes possible through techniques such as automatic quantum circuit encoding (AQCE) [1]. However, conventional studies have largely relied on regular TN structures such as MPS, TTN, or MERA, which are often inefficient for general vector data lacking an underlying Hamiltonian or spatial structure. Although the usefulness of TTN structural optimization has been demonstrated in several cases [2–5], its practical adoption has been limited by implementation complexity.

In this talk, we introduce TTNOpt [6], a software package that first decomposes input vectors into an initial MPS and then automatically optimizes the TTN structure based on entanglement. This enables compact and accurate representation even for data with hierarchical or non-local correlations, while using significantly smaller bond dimensions. Building on TTNOpt, we outline the pipeline "vector → optimized TTN → quantum circuit", and discuss how TTNs surpass MPS in representational power and facilitate scalable quantum state preparation.

* This work is partially supported by JSPS KAKENHI Grant No. JP22H01171, JP21H04446, JP21H05182, and JP21H05191, and by the COE research grant in computational science from Hyogo Prefecture and Kobe City through Foundation for Computational Science. We also acknowledge support from MEXT Q-LEAP Grant No. JPMXS0120319794, JST COI-NEXT Grant No. JPMJPF2014, and JST CREST Grant No. JPMJCR24I1.

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