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Automatic Structural Search of Tensor Network States including Entanglement Renormalization

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When the entanglement structure of the quantum state of interest is non-uniform in real space, accurately representing the state with a limited number of degrees of freedom hinges on appropriately configuring the Tensor Network (TN) to align with the entanglement pattern. Although TN states including entanglement renormalization (ER) can encompass a wider variety of entangled states, a proposal has yet to show a structural search of ER due to its high computational cost and the lack of flexibility in its algorithm. In this study, we conducted an optimal structural search of TN, including ER, based on the reconstruction of their local structures with respect to variational energy. Firstly, we demonstrated that our algorithm for the spin-1/2 tetramer singlets model could calculate exact ground energy using the multi-scale entanglement renormalization ansatz (MERA) structure as an initial TN structure. Subsequently, we applied our algorithm to the random XY models with the two initial structures: MERA and the suitable structure underlying the strong disordered renormalization group. We found that, in both cases, our algorithm achieves improvements in variational energy, fidelity, and entanglement entropy. The degree of improvement in these quantities is superior in the latter case compared to the former, suggesting that utilizing an existing TN design method as a preprocessing step is important for maximizing our algorithm's performance.

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