Categorical Tensor Networks

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Abstract
We examine the use of the mathematics of category theory in the description of quantum states by tensor networks. This approach enables the development of a categorical framework allowing a solution to the quantum decomposition problem. Specifically, given an n-body quantum state \( \psi \), we present a general method to factor \( \psi \) into a tensor network. Moreover, this decomposition of \( \psi \) uses building blocks defined mathematically in terms of purely diagrammatic laws. We use the solution to expose a previously unknown and large class of quantum states which we prove can be sampled efficiently and exactly. This general framework of categorical tensor network states, where a combination of generic and algebraically defined tensors appear, enhances the theory of tensor network states.

A normal form on states
Results in a wide class of quantum states that are efficient to sample.

The tensors in a CTNS are fully defined

W-state on n-qubits

Solve 3SAT by network contraction

= \( \text{fsat}(x_1, x_2, \ldots, x_n) \)