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Building separable approximations for quantum states via neural networks

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Finding the closest separable state to a given target state is a notoriously difficult task, even more difficult than deciding whether a state is entangled or separable. To tackle this task, we parametrize separable states with a neural network and train it to minimize the distance to a given target state, with respect to a differentiable distance, such as the trace distance or Hilbert-Schmidt distance. By examining the output of the algorithm, we obtain an upper bound on the entanglement of the target state, and construct an approximation for its closest separable state. We benchmark the method on a variety of well-known classes of bipartite states and find excellent agreement, even up to local dimension of $d = 10$, while providing conjectures and analytic insight for isotropic and Werner states. Moreover, we show our method to be efficient in the multipartite case, considering different notions of separability. Examining three and four-party GHZ and W states we recover known bounds and obtain additional ones, for instance for triseparability.

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