Training iterated protocols for distillation of GHZ states with variational quantum algorithms

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Abstract

Since the pioneering work [1] there has been considerable effort devoted to the theory of distilling multipartite entangled states [2] and, especially, GHZ states. We present optimized distillation schemes for preparing GHZ states. Our approach relies on training variational quantum circuits with white noise affected GHZ states as inputs.

Optimizing for a single iteration of the scheme, we find that it is possible to achieve an increased fidelity to the GHZ state, although further iterations decrease the fidelity. The same scheme, acting on coherently distorted pure-state inputs, is effective only in certain special cases.

We show that radically different results can be achieved, however, when one optimizes for the output after two iterations of the protocol. In this case, the obtained schemes are more effective in distilling GHZ states from inputs affected by white noise. Moreover, they can also correct several types of coherent pure-state errors.

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References

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[2] W. D¨ur, H. Aschauer, H.-J. Briegel, Multiparticle entanglement purification for graph states, Phys. Rev. Lett. 91 (2003) 107903.

Figures

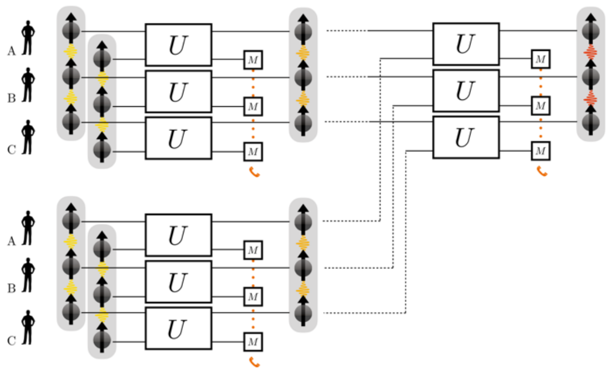

Figure 1: A schematic diagram illustrating the nonlinear protocol employed for GHZ distillation, considering a scenario involving two iterations. Three parties share two noisy GHZ states on which they perform local operations (denoted by the unitary operator *U*) and subsequent measurements (*M*). They communicate through classical channels to post-select the states by a consensus process for the next iteration.

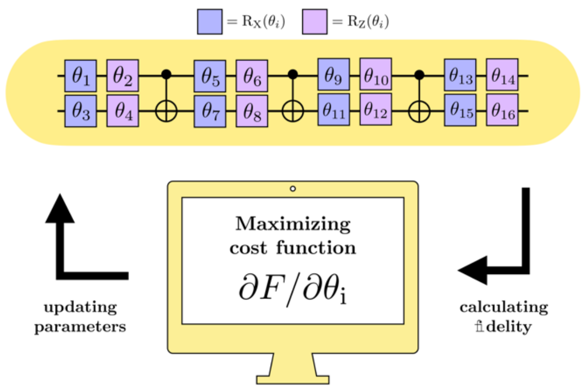

Figure 2: A schematic view of the variational algorithm consisting of a quantum circuit constructed by tuneable parametric gates of R_X and R_Y rotations, as well as CNOT gates. The circuit encircled in the yellow box (representing the unitary *U*) is employed by each party independently at their location. Once each protocol step has been executed by the parties, the cost function (i.e., the fidelity to the GHZ state) is computed. Subsequently, a classical gradient ascent algorithm is employed to calculate the derivatives of the fidelity with respect to the parameters. The parameters are then updated according to the derivatives and the variational algorithm is run until the output fidelity converges to a final value.