Shadow Tomography of Quantum States with Prediction

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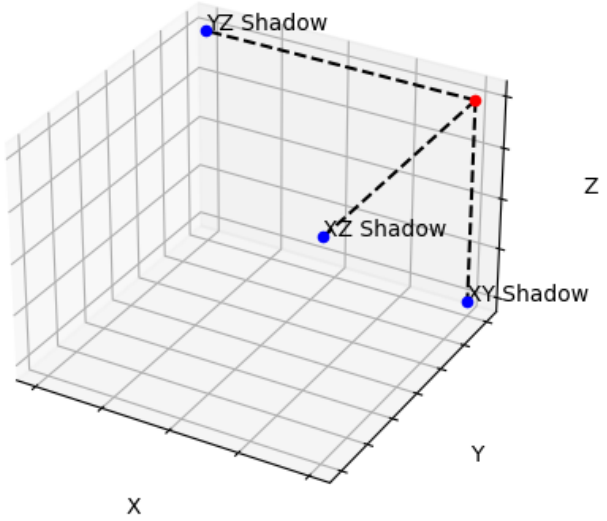
Problems & Ideas

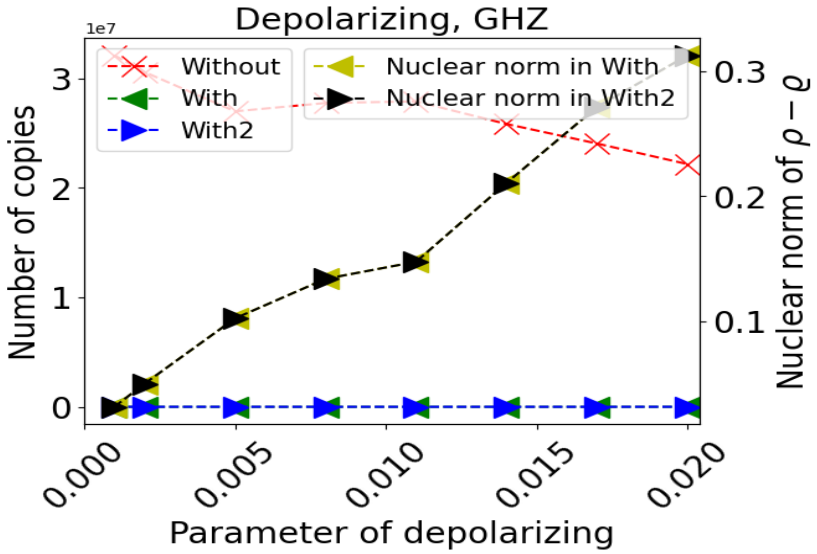
- Problems of conventional shadow tomography:
  - Currently, quantum resources are limited, so sample complexity is an important metric for quantum algorithms.
  - To achieve ε-accuracy, the conventional algorithm has a sample complexity with respect to $\varepsilon^{-1}$of order 4.
- Ideas: In practice, the unknown quantum state ρ should be generated by real-world quantum devices so that its predictions may be available.

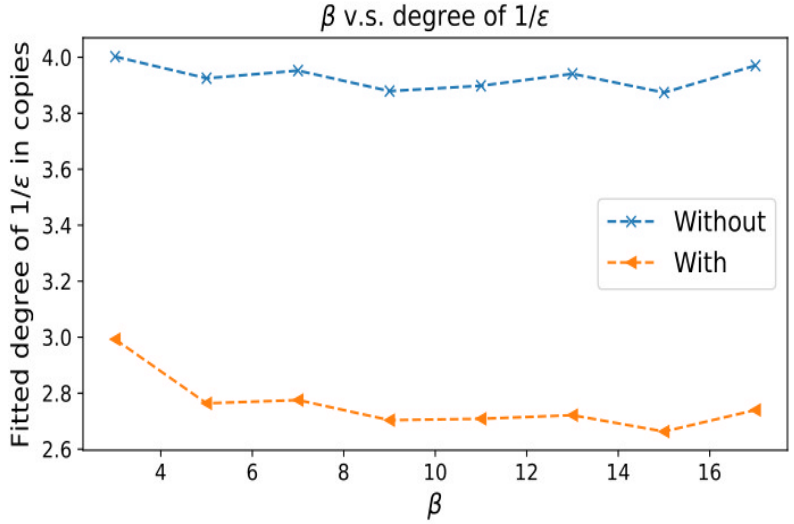


Shadow tomography is about getting a partial description of the unknown quantum state, rather than the full description. The red dot represents the state that has shadows on some surfaces, like the XY-plane.

Main Contributions

- Contributions:
  - A modified online learning algorithm that can leverage classical prior knowledge about the unknown quantum state ρ;
  - Given a prediction ϱ, the upper bound of the sample complexity is scaled by the trace distance between ρ and ϱ, which is at most 2;
  - If the trace distance between ρ and ϱ is $\Theta(\varepsilon)$, the order of ε^{-1} in the sample complexity can be reduced from 4 to 3.





Experiment results by classical simulations. Left: consider the shadow tomography task of the output of a state preparation circuit of 4-qubit GHZ state that suffered from depolarizing noise, the average copies needed for conventional and our algorithm; Right: suppose the trace distance between ρ and ϱ is fixed as β, the fitted degree between copies needed and ε^{-1}.