Dimension Reduction in Quantum Simulation of Stochastic Processes

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Abstract

Quantum simulation of stochastic processes by translating their hidden Markov model (HMM) representations into quantum circuits can provide significant advantages in the scaling of memory and time resources compared to classical approaches. Enhancement of these advantages for the class of deterministic HMMs has been achieved through lossy compression of their tensor network representations, realising a quantum analogue of dimension reduction. For many stochastic processes however, there exist more parsimonious representations in terms of nondeterministic HMMs. In this work, we extend such tensor network techniques for use with nondeterministic HMMs, demonstrating accurate compression and cementing quantum memory advantages for this more general class. We benchmark our approach with HMM models of stochastic processes from various domains in the quantitative science, such as sequence prediction for protein families. We will discuss possible generalisations to more complex processes, and applications to other elements of stochastic modelling.

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