Classical and Quantum Memory Characterisation of Process using Neural Networks

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Characterizing the dynamics of an open quantum system is of significant importance. In the recently developed process matrix approach to open quantum systems, the presence of Markovianity or non-Markovianity can be inferred from the structure of the process matrix [1, 2]. Importantly, for non-Markovian processes, where the noise across time is correlated, a finer characterization of processes as classical and quantum memory is relevant from the perspective of developing error correction protocols [3]. However, the certification of the type of memory in the environment traditionally requires the knowledge of the complete process matrix, determining which is a resource expensive task [4, 5]. In this work, we develop a neural network based machine learning algorithm, which classifies a given dynamics into classical and quantum memory. The algorithm predicts the class based on the statistics from an informationally incomplete set of operations, thereby significantly reducing the resources to detect the type of non-Markovianity in the process. For the training dataset, we use the simulated processes, namely, quantum memory class is generated using a sequence of Haar random unitaries and classical memory class using a special class of interaction Hamiltonian. Moreover, using a semidefinite program (SDP) approach to generate random process matrices corresponding to multi-time processes, we apply the unsupervised clustering method on the resulting dataset to separate different classes of non-Markovianity.

References

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