Enhanced accuracy in dimensionally-constrained quantum models

Chengran Yang[a], Andrew Garner[b], Feiyang Liu[c], Nora Tischler[d], Jayne Thompson[f], Man-Hong Yung[c], Mile Gu[a], Oscar Dahlsten[f]

[a]*School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore*

[b]*Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Vienna Austria*

[c]*Department of Physics, Southern University of Science and Technology, Shenzhen, China*

[d] *Centre for Quantum Dynamics, Griffith University, Brisbane, , Australia*

[f] *Horizon Quantum Computing, 29 Media Circle, Singapore*

In data analytics, the curse of dimensionality is a well-acquainted adversary. As we seek to make predictions from time-series data drawn from processes of ever-growing complexity, modelling the possible future effects from all possible past observations becomes quickly intractable. Even when the time-series data is binary, the cost of accounting for temporal correlations in the last n time-steps grows as 2n – making the exact simulation of highly non-Markovian processes computationally infeasible.

Here, we discuss recent work that quantum models can yield a better trade-off between accuracy and model dimension [1]. These machines encode relevant past information within quantum memory. As they execute a time-series simulation, information about the past events of a stochastic process becomes encoded in the classical and quantum correlations between the output tape and the machine's memory register.

- Given models of a fixed memory dimension, quantum models can achieve accuracies surpassing optimal classical counterparts.
- There exist families of progressively more non-Markovian processes that require increasing classical memory dimensionality to model, and yet can be modelled by a quantum machine of bounded dimension.

We present an algorithm to infer such dimensionality-reduced quantum models directly from experimental data and illustrate experiments implementing such algorithms on an IBM quantum computer ("ibmq athens"). We show that despite the significant noise in such near-term devices, our models can achieve accuraces provably unattainable in their classical counterparts.

[1] Chengran Yang, Andrew Garner, Feiyang Liu, Nora Tischler, Jayne Thompson, Man-Hong Yung, Mile Gu, Oscar Dahlsten, *Provable superior accuracy in machine learned quantum models* arXiv:2105.14434 (2021)