Inferring the Complexity of Quantum Causal Modelling

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Complex, stochastic processes underpin quantitative science. It is therefore of paramount importance to study and understand the behaviour of such processes for the crucial twin purposes of modelling and prediction. These tasks are typically resource-intensive, motivating the need for methods that ameliorate these requirements. A promising recent development to this end [1, 2], using a cross-disciplinary blend of tools from quantum and complexity science, has highlighted that quantum simulators can operate with much smaller memories than the minimal possible classical models [3, 4], while providing equally accurate predictions.

Presently, these efficient quantum models are designed with prior knowledge of the minimal classical model, necessitating the use of classical model inference algorithms when applied to real data. Here, we introduce a new inference protocol specifically designed for constructing quantum models, circumventing certain drawbacks of the classical approach that need not manifest in the quantum domain [5]. Crucially, our protocol can be used to both blindly infer efficient quantum models of a given pattern or time series, and bounds on the associated structural complexity. We show that our protocol is robust to statistical imperfections arising from finite data, and does not require any smoothing of probabilities typically associated with classical algorithms. Our results form a key step in the application of this emerging field to real world systems.

References

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