Reinforcement learning via single-photon quantum walks, and perspectives on explainable quantum machine learning

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This document is the abstract for an application to give a talk at the 17th Granada Seminar, *Machine Learning and Physics: Quantum, Classical and Applications*. It covers the content of:

Reinforcement learning and decision making via single-photon quantum walks by Fulvio Flamini*, Marius Krumm*, Lukas J. Fiderer, Thomas Müller, Hans J. Briegel, arXiv:2301.13669 .

In this talk, a quantization of a classical reinforcement learning method called *Projective Simulation* (PS) is presented. In classical PS, a decision making process is modeled as a random walk of an excitation on a memory graph. Our quantum PS uses a quantum random walk of a single photon in a tunable interferometer network. Since the update rule of classical PS relies on increasing transition probabilities of individual trajectories, we instead use a variational approach with a loss function inspired by classical PS. Here, the concept of causal diamonds allows to drastically reduce the number of parameters for which a gradient must be calculated.

Classical PS was designed as a machine learning algorithm with built-in interpretability and explainability. Explainable AI is an important topic in classical machine learning research, and many nations are turning explainable algorithmic decisions into a legal requirement for high risk applications such as medical diagnosis. However, contemporary quantum machine learning research focuses almost entirely on the search for a quantum advantage, neglecting the extra challenges that quantum physics poses for interpretability. Using our Quantum PS proposal, we discuss several strategies that help to make quantum machine learning more understandable: Partial traceability of excitations, and modularity of the quantum or interferometer circuit.

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