Quantum-Enhanced Agents: Can Quantum Machines Better Adapt to Complex Environments?

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The world is awash with complex, interacting systems. Predators chasing prey, investors trading stocks, grandmasters playing chess: all share that they process information from their environment and act appropriately in response. As the processes, we seek to tackle, automate or adapt to become ever more complex, success requires executing strategies that maintain consistency over ever-greater timescales. This, in turn, requires tracking ever-growing amounts of data, incurring additional computational or physical resource costs.

Could the quantum mechanical laws that govern fundamental particles provide a tool to surmount this challenge? Such prospects may first sound surprising. How can a theory designed to model the dynamics at the level of photons and electrons aid in the understanding of systems with no quantum effects?

In this talk, we detail recent work illustrating that quantum-enhanced agents - automated machines capable of processing data quantum mechanically – can better isolate essential data for modelling, adapting, or manipulating complex environments [1]. We demonstrate how this leads to reduced memory resource costs and how this advantage can scale without bound when optimal performance necessitates tracking information about events far into the past. Time permitting, we outline ongoing research in potential applicative and fundamental consequences, from potential for quantum machines to reduce fundamental energetic costs of executing complex strategies to improved accuracy in classifying time-series data in memory-limited domains [2-3].

[1] Thomas Elliott, Mile Gu, Andrew Garner, Jayne Thompson, *Phys. Rev. X 12, 011007* (2022).

[2] Jayne Thompson, Paul Riechers, Andrew Garner, Mile Gu, *In Preparation*

[3] Keith Ng, Jayne Thompson, Mile Gu, *In Preparation*