REINFORCEMENT LEARNING ALGORITHM FOR ADAPTIVE QUANTUM MEASUREMENT INCLUDING NOISE AND LOSS*

Pantita Palittapongarnpim†
Institute for Quantum Science and Technology, University of Calgary, Alberta T2N 1N4, Canada

Peter Wittek
ICFO-The Institute of Photonic Sciences, 08860 Castelldefels (Barcelona), Spain
University of Borås, 50190 Borås, Sweden

Barry C. Sanders
Institute for Quantum Science and Technology, University of Calgary, Alberta T2N 1N4, Canada
Program in Quantum Information Science, Canadian Institute for Advanced Research, Toronto, Ontario M5G 1Z8, Canada

Adaptive quantum-enhanced metrology seeks to measure a parameter with precision that scales with the number of resource superior to the standard quantum limit (SQL) scaling. Feedback policies that achieve better than SQL scaling for interferometric phase estimation can be found using reinforcement learning algorithms. However, when the parameter is noisy, the algorithm is not able to find successful policies for measurements that use more than 45 photons.

We devise a noise-resistant learning algorithm for adaptive phase estimation that includes small Gaussian-like phase noise. Our algorithm introduces an enhanced differential evolution algorithm for optimization; our variant of this reinforcement learning algorithm is its robustness against noise. ACCEPT-REJECT criteria are introduced to ensure that the algorithm terminates as soon as a successful result is obtained.

Our reinforcement learning algorithm successfully finds feedback policies that deliver precision scaling exceeding that obtained by SQL for measurements using up to a hundred photons. Effective feedback policies have been obtained despite the presence of substantial phase noise whose standard deviation is as large as one radian. Our tool has potential for applications to adaptive parameter estimation and control of multiple parameter channels in quantum communication and metrology.

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†*E-mail:* ppalitta@ucalgary.ca