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Quantum Machine Learning Towards the Development of Automated Analysis of Data from Large-Scale Gamma-Ray Spectrometers

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There are many outstanding fundamental questions in nuclear physics that are described in the NSERC Subatomic Physics Long Range Plan. For several of these main research drivers such as " How does nuclear structure emerge from nuclear forces and ultimately from quarks and gluons?", gamma-ray spectroscopy is the investigative tool of choice. However, analysis of data from large-scale gamma-ray spectrometers is often a bottleneck for progress due to the extremely complex nature of the decays of excited nuclear states. In some cases, thousands of individual gamma rays must be analyzed in order to construct excited state decay schemes. To date, this is largely done laboriously by hand with the final result depending on the skill of the individual performing the analysis.

The essence of this research lies in its multi-pronged approach, enabling a rigorous comparison of two dominant machine learning paradigms: supervised and unsupervised techniques. The ultimate goal is to determine the most effective framework for solving problems of this nature, and subsequently to enhance the chosen framework by integrating quantum computing, harnessing the power of qubits and quantum operations to overcome the computational restrictions inherent in classical computing.

The outcome of this work stands to offer the additional benefit of acting as a prototype for novel quantum machine learning enhancements that could extend well beyond this particular application into associated fields such as particle physics, medical physics, or any other field that encounters similar limitations in computing power when dealing with multi-body problems or calculations in higher dimensional spaces.

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