Hybrid Classical-Quantum Learning Applications for Noisy Intermediate-Scale Quantum Computing

Mots clés :

- Directeur de thèse : Elham KASHEFI
- Co-encadrant(s) :
- Unité de recherche : Laboratoire d'informatique de Paris 6
- Ecole doctorale : École Doctorale Informatique, Télécommunications, Électronique de Paris
- Domaine scientifique principal : Sciences de l'information et de la communication

Résumé du projet de recherche (Langue 1)

Recently quantum algorithms have seen a flurry of new advances in the areas of optimisation and machine learning. Starting with the seminal algorithm of Harrow, Hassidim, and Lloyd for solving systems of linear equations, many quantum machine learning applications have appeared, including for clustering, data fitting, recommendation systems, and on Gradient Descent proposing. Meanwhile, Noisy Intermediate-Scale Quantum (NISQ) technology is already on the way. Different manufacturers, including Google, IBM and Intel, have already announced quantum devices of 49-50 superconducting qubits, while devices with few tens of qubits based on ion traps are also available, for example at NIST (USA) or IQOQI (Austria). These devices consist of noisy qubits, some noisier than others, and understanding their real computational power is important and not straightforward. Nevertheless, announcements of quantum devices performing computations seemingly infeasible with classical computers are imminent. However, these devices will not be able to perform many of the most famous quantum learning algorithms thought to demonstrate exponential speedups over classical algorithms. While, they could provide an efficient solution to other problems which cannot be solved in polynomial time by purely classical means. Many of the aforementioned proof of principle problems utilise the measurement process inherent in quantum computation by generating samples from a quantum distribution. Typically, the distribution is sampled by applying a sequence of quantum gates and measurements to some initial state. If this sequence consists of quantum gates drawn from a 'universal' set, we can sample from any quantum distribution. A more restricted scenario is one where we are not permitted to utilise the full suite of universal gates. The motivation here is to generate circuits that are simpler to implement experimentally on NISQ devices. In this thesis we target to incorporate these initial sampling problems into useful applications in such a way to keep a provable quantum advantage, but in a context with direct applicability. For this, we turn to generative modeling in quantum machine learning, the task of training an algorithm to generalise from a finite set of samples drawn from a data set, by learning the underlying probability distribution from which these samples are drawn. The model can then generate new samples from the target distribution itself. The particular areas that we aim to target...