Distributed Quantum Machine Learning

Project Description

Quantum computing leverages the principles of quantum mechanics to process information in fundamentally new ways, enabling it to solve certain complex problems—like cryptography, optimization, and molecular simulation—much faster than classical computers. Its significance lies in its potential to revolutionize fields from drug discovery to artificial intelligence. In this context, quantum machine learning (QML) has gained significant research attention in recent years, particularly quantum variational classifiers, which are crucial because they can be implemented on today's noisy and limited quantum processors. Quantum variational classifiers are QML models based on parameterized quantum circuits, where classical optimization adjusts quantum parameters to minimize a cost function. Circuit cutting is a technique in quantum computing that distributes the execution of a quantum circuit across multiple quantum processors using classical communication. This method is particularly suited for near-term devices, as it eliminates the need for quantum communication. However, relying on classical communication instead of quantum communication introduces an exponential overhead in the sampling rate needed to reconstruct the output of the distributed quantum circuit. Applying circuit cutting to quantum machine learning is challenging due to this exponential overhead. In this project, we aim to implement circuit cutting on various circuits used in quantum machine learning using Pennylane or Qiskit, identify the fundamental practical challenges in this area, and develop strategies to mitigate them.

What you'll do

- Gaining the necessary background for the project through reviewing key papers, relevant book chapters, and implementing related code
- Designing and implementing quantum and classical machine learning models using Python libraries such as PennyLane and PyTorch
- Implementing distributed quantum circuits efficiently

Requirements

- Background in either machine learning or quantum computing (Both are not required; candidates with experience in one area will be supported in building knowledge in the other.)
- Experience with Python, including the implementation of either classical machine learning models or quantum circuits