Quantum computing in the NISQ era

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Quantum computing leverages principles of quantum mechanics and computational theory to manipulate the states of physical quantum systems in order to solve specific problems. By naturally exploiting purely quantum phenomena such as superposition and entanglement, quantum computers can perform processes that are extremely difficult to simulate classically. This has led many researchers to believe that quantum computers have the potential to be inherently more powerful than any classical computer.

However, in the current era of Noisy Intermediate-Scale Quantum (NISQ) devices, the practical capabilities of quantum computers remain limited. In this talk, we will introduce the fundamental principles and mechanisms of quantum computing, and explore standard algorithms that, under ideal conditions, demonstrate provable quantum advantage over the best-known classical algorithms. We will then discuss the main practical limitations of today's quantum computing technologies and present a recent computational paradigm — variational quantum computing — which can partially mitigate these challenges. Finally, we will address open questions and future directions from both practical and algorithmic perspectives.