Day-18 Task

Variational Quantum Algorithms

↳ Hybrid classical-quantum algorithms

↳ Use classical algorithms to optimize parametrized quantum circuits.

Parametrized quantum circuit

↓

Quantum measurement

↓

Classical optimization

Updated Parameters

↳ Iteratively finds a solution

↳ A bridge between today's quantum computers and future fault-tolerant ones

↳ Leverages quantum mechanical principles

↳ Circuits are small enough to run on today's computers.

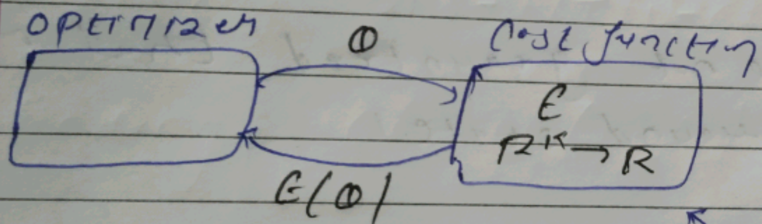
↳ Adapted to a wide range of problems

VQA Challenges

- Limited by the noise present in current quantum computers.
- May find suboptimal solutions.
- Limited problem sizes because of qubit count, error rates and coherence times

VQE: Motivation

Goal: Minimize the energy of a system



$E: R^k \to R$
Parameters
↓
real numbers

Quantum Computer

- Initialize Params θ_0
- Repeat:
  - Evaluate $E(\theta_i)$
  - Choose θ_{i+1}

Cost function: what is a Hamiltonian?

If the system is in state $|\psi\rangle$, the energy of the system is: $\langle\psi|H|\psi\rangle$

We want to know the minimum energy of H.
In other words: the lowest eigenvalue, λ_0.

$$\min_{|\psi\rangle} \langle\psi| H |\psi\rangle$$

$$= \langle\psi_0| H |\psi_0\rangle$$

$$= \lambda_0$$

Trial states + The Variational Principle

Parameterize some continuous subset $\mathcal{M}_\kappa$ of quantum states.

$$|\psi(\theta)\rangle \in \mathcal{M}_\kappa \subset \mathbb{C}^{2^n}$$

where/i.e. $\dim(\theta) = O(P \cdot l \cdot n)$

Note, we are not guaranteed that $\mathcal{M}_\kappa$ contains the ground state!

WHP: $|\psi_0\rangle \notin \mathcal{M}_\kappa$.

Cost function Breakdown

Compiled into a quantum circuit + Generate Pulse sequences for quantum circuit	Execute circuit and prepare trial state $\lvert\psi(\theta)\rangle$	Estimate expectation value of H $\langle\psi(\theta)\lvert H\rvert\psi(\theta)\rangle$