Quantum Computation - Exam

Checkboxes

1/1 point (graded)

A quantum compiler has a different role from a compiler on a classical computer for a language like C. A compiler on a classical computer translates a high-level language to machine code. A quantum programming language is already low-level, working at the level of quantum logical gates. So what does a quantum compiler actually do?

- [x] Converts the gates used to the gates available on the hardware.
- [ ] Creates a pulse sequence to control the quantum processing unit.
- [x] Maps multi-qubit operations to the connectivity structure of the qubits in the hardware.
- [x] Decomposes user-defined unitary operations to elementary gates.

Enviar

Correcto (1/1 punto)

Multiple Choice

1/1 point (graded)

Imagine that you want to apply a CNOT where qubit 0 controls qubit 1. The hardware, however, can only implement the CZ gate defined as $\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}$. It can also implement any single-qubit gate. How would you map CNOT to this quantum computer?

- Apply an X gate on qubit 1, apply CZ where qubit 0 controls qubit 1. Then apply X on qubit 1 again.
- Apply an X gate on qubit 0, apply CZ where qubit 0 controls qubit 1. Then apply X on qubit 1.
- (selected) Apply an H gate on qubit 1, apply CZ where qubit 0 controls qubit 1. Then apply H on qubit 1 again.
- Apply an Z gate on qubit 0, apply CZ where qubit 0 controls qubit 1. Then apply Z on qubit 0 again.

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Enviar

✔ Correcto (1/1 punto)

Multiple Choice

1/1 point (graded)

The Ry(θ) gate is defined as $\begin{bmatrix} \cos(\theta/2) & -\sin(\theta/2) \\ \sin(\theta/2) & \cos(\theta/2) \end{bmatrix}$. What is the outcome if we apply this gate with $\theta = \pi$ on $|1\rangle$

- $|0\rangle$
- $|1\rangle$
- $-|0\rangle$
- $(|0\rangle + |1\rangle)/\sqrt{2}$

Enviar

Correcto (1/1 punto)

Multiple Choice

1/1 point (graded)

We evolve the Hamiltonian $H = \sigma^Z$ on a single qubit for some time t and we would like to reverse it. What's the corresponding $U^\dagger$?

- $\exp(-i\sigma^Z t)$
- $\exp(i\sigma^Z t)$
- $\exp(-i\sigma^{Z\dagger} t)$

Enviar

Correcto (1/1 punto)

Numerical Input

1/1 point (graded)

We perform annealing with a linear schedule and we know that the minimum gap for $H\left(t\right)$ for any t during the transition is 0.2. What's the approximate speed limit?

25 ✔

25

Enviar

✔ Correcto (1/1 punto)

Checkboxes

1/1 point (graded)

In adiabatic quantum computing and quantum annealing, we typically start annealing with the Hamiltonian $H=\sum_i \sigma_i^X$, which is just the transverse field on all sites. Why?

- [x] It is a non-interacting system, so each site has an independent ground state, making it easy to achieve.
- [ ] The transverse field is easily switched to the external field in the classical Ising model.
- [ ] This Hamiltonian ensures a linear schedule for the adiabatic transition.
- [x] The ground state is the uniform superposition, allowing the exploration of the solution space of the classical Ising model.

✔

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✔ Correcto (1/1 punto)

Numerical Input

1/1 point (graded)

What is the largest n for which you can embed a K_n complete graph in a single unit cell in a Chimera graph?

5 ✔

5

Enviar

✔ Correcto (1/1 punto)

Multiple Choice

1/1 point (graded)

A quantum annealer gives some value as the lowest energy solution out of a thousand samples. How do you know it is optimal?

- ○ It is always optimal, since the annealer follows the adiabatic pathway.
- ● We don't know. We can only compare it to the best known classical solution.
- ○ It is easy to verify exactly with a polynomial time classical algorithm.

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Checkboxes

1/1 point (graded)

Superconducting architectures are...

- [x] The most popular target for implementations.
- [x] Use silicon-based fabrication.
- [ ] Can have arbitrary connectivity between qubits.
- [ ] Have a long coherence time.

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Correcto (1/1 punto)

Multiple Choice

1/1 point (graded)

In the Trotterization of the adiabatic transition, we alternate the time evolution between the mixer and target Hamiltonians, so the overall evolution is written as $U \approx U(H_0, \beta_0)\, U(H_1, \gamma_0) \ldots U(H_0, \beta_p)\, U(H_1, \gamma_p)$. What is the role of γ_i and β_i?

- ( ) The coupling and field strengths of the target and the mixer Hamiltonians.
- (•) The length of time evolution for the two Hamiltonians at each step.
- ( ) They are hyperparamater not affected by optimization.

Enviar

✔ Correcto (1/1 punto)

Checkboxes

1/1 point (graded)

The p parameter in QAOA...

- [ ] Is optimized over.
- [x] Controls the accuracy of the approximation.
- [x] Controls the depth of the circuit.

✔

Enviar

✔ Correcto (1/1 punto)

Multiple Choice

1/1 point (graded)

What's the temperature in the approximate Boltzmann distribution if you perform quantum annealing at finite temperature?

- ○ The temperature that should be of the dilation refrigerator.
- ◉ It is an effective temperature that you have to calculate based on the samples.
- ○ It is an effective temperature that you choose depending on the thermal state you want to sample.

Enviar

Correcto (1/1 punto)

Multiple Choice

1/1 point (graded)

You are preparing the thermal state of the mixer Hamiltonian in the quantum approximate thermalization protocol. The inverse temperature β is infinite. What's the starting state before you run QAOA?

- $\psi\rangle = \sqrt{2\cosh 1/T}\sum_{z\in -,+} e^{-z/T}|z\rangle\otimes|z\rangle$
- The uniform superposition.
- $\mathbb{I}/2.$

Enviar

Correcto (1/1 punto)