

Quantum Algorithm Survey: Cont'd

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Quantum Algorithms for Linear Algebraic Problems

Linear equation systems

$$A\vec{x} = \vec{b}, \text{ given oracle access to } A, \vec{b}, \text{ generate } \frac{\vec{x}}{\|\vec{x}\|}$$

- ▶ Ref. [HHL]: the first quantum algorithm (poly-log dimension dependence) based on phase-estimation.
- ▶ Ref. [CKS]: poly-log error dependence based on approximation theory, linear combination of unitaries (LCU), quantum walks and Hamiltonian simulation.

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- ▶ Singular value decomposition, matrix factorization,
- ▶ Spectral method, linear sketches,

Quantum Algorithms for Machine Learning

Many proposals

- ▶ Quantum algorithms for super-vector machines, principle component analysis, ...

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- ▶ Quantum algorithms for support-vector machines, principle component analysis, ...
- ▶ Quantum algorithms for data fitting, geometric analysis of data, linear regression ...

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Also note that:

- ▶ No much quantum speed-up in the sense of computational learning theory.

Quantum Algorithms for Optimizations

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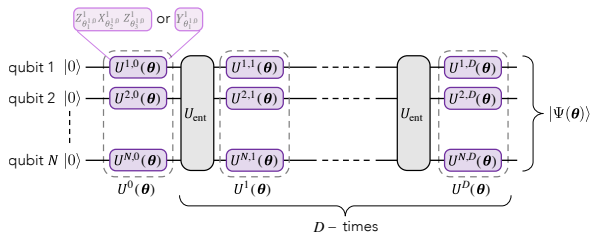
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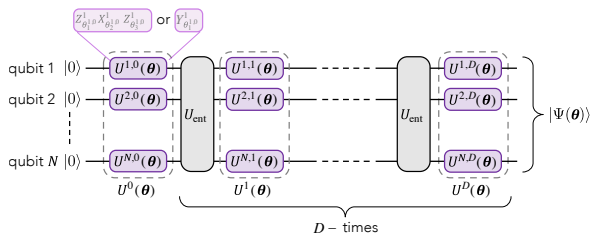
Open questions

- ▶ Concrete examples of SDP with provable quantum speed-up.
- ▶ Optimization beyond SDPs.
- ▶ Quantize other classical techniques.

Variational Methods based on Short-depth Circuits



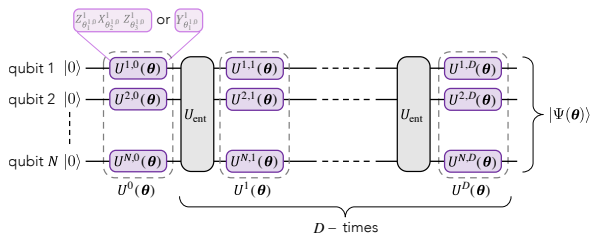
Variational Methods based on Short-depth Circuits



Proposals

- Quantum chemistry: ground energy of Hamiltonians.

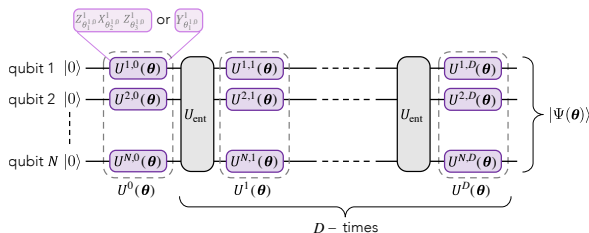
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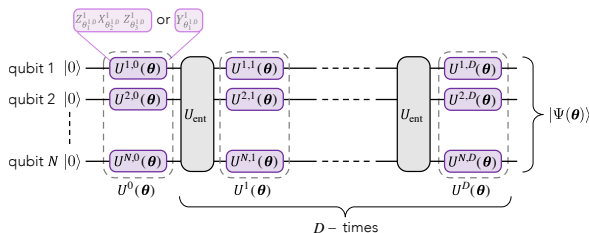
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- ▶ Quantum chemistry: ground energy of Hamiltonians.
- ▶ Optimization: Quantum Approximate Optimization Algorithm (QAOA)
- ▶ Quantum Neural Network.

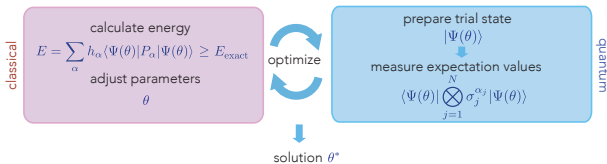
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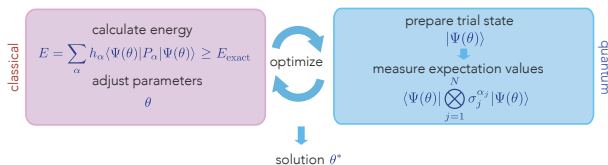
Proposals

- ▶ Quantum chemistry: ground energy of Hamiltonians.
- ▶ Optimization: Quantum Approximate Optimization Algorithm (QAOA)
- ▶ Quantum Neural Network.
- ▶ Representing kernels, e.g., applied in, support vector machines (SVM)

Classical-Quantum Hybrid Algorithms

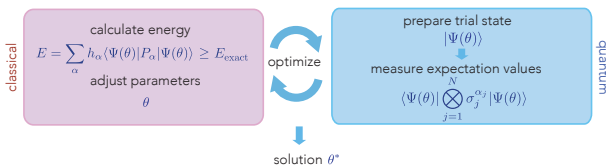


Classical-Quantum Hybrid Algorithms



- Reasonable scenario for algorithm design on near-term quantum devices.

Classical-Quantum Hybrid Algorithms



- ▶ Reasonable scenario for algorithm design on near-term quantum devices.
- ▶ Heterogeneous computing, architecture, system, programming languages.

Thank You!!

Q & A