Constrained QAOA with autoencoders

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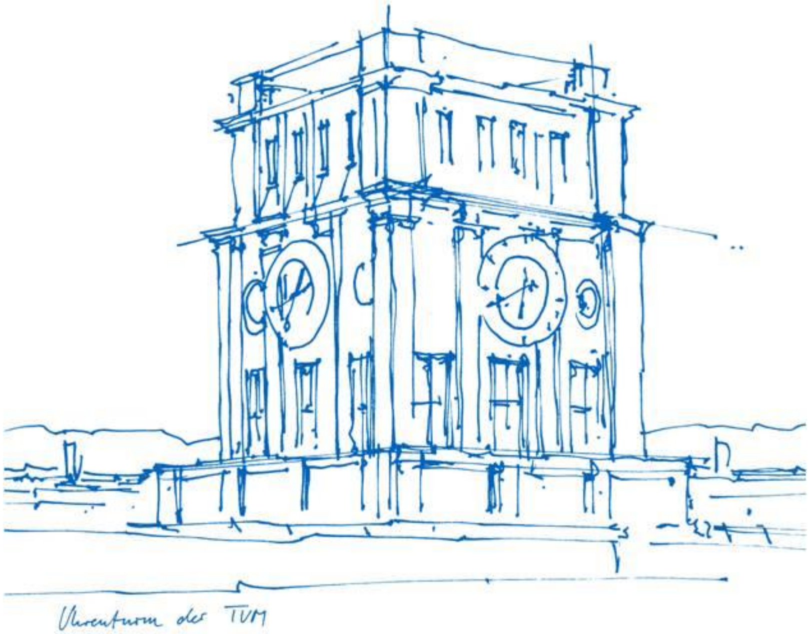
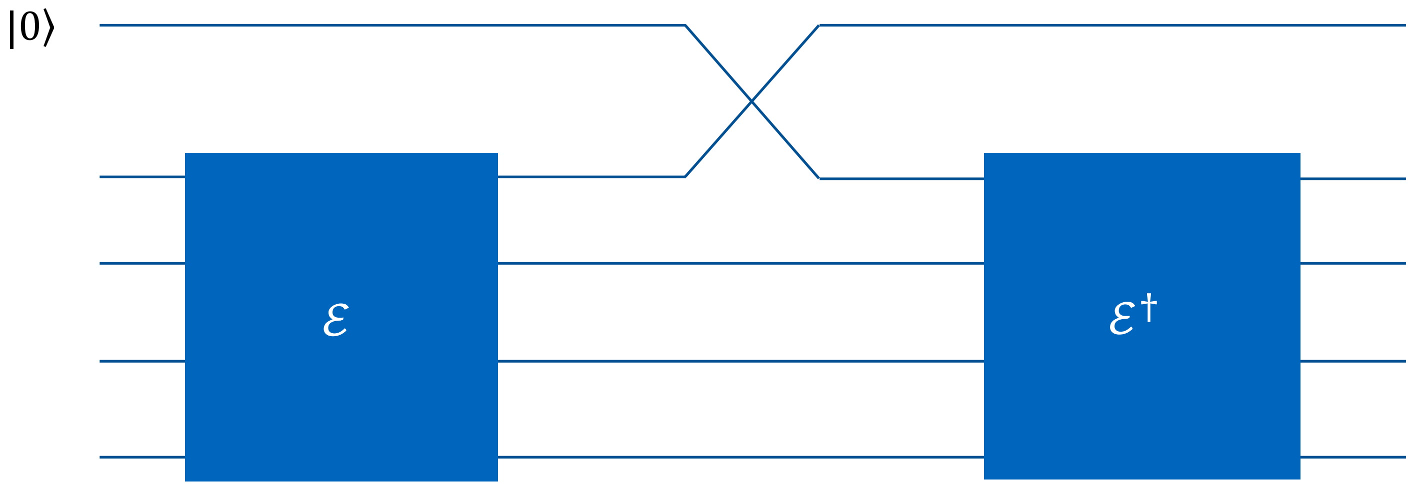


Constrained QAOA with autoencoders

Burak Mete

Prof. Christian Mendl

Quantum Autoencoder



Quantum Approximate Optimization Algorithm (QAOA)

Based on:

Adiabatic Theorem: *A physical system remains in its instantaneous eigenstate if a given perturbation is acting on it slowly enough and if there is a gap between the eigenvalue and the rest of the Hamiltonian's spectrum.*

Say,

$$H(t) = \left(1 - \frac{t}{T}\right) M + \frac{t}{T} C \qquad \text{for } t \in [0, T]$$

Quantum Approximate Optimization Algorithm (QAOA)

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Problem specific

Something simple

Quantum Approximate Optimization Algorithm (QAOA)

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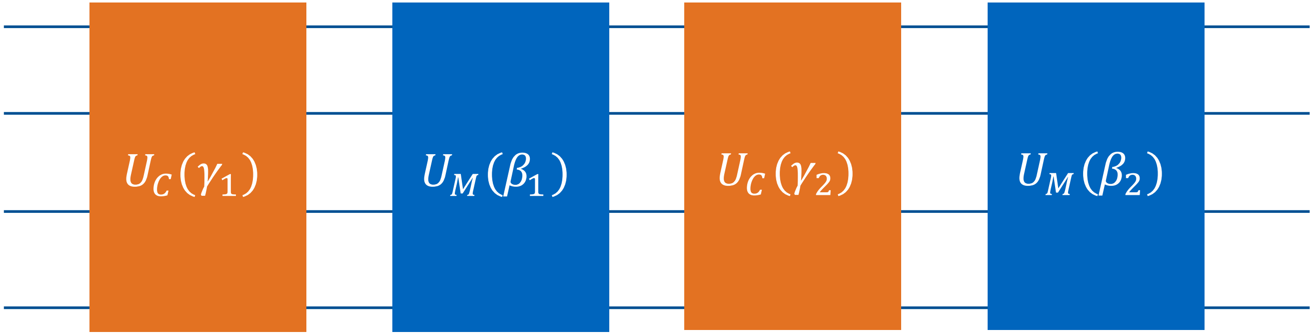

Quantum Approximate Optimization Algorithm (QAOA)

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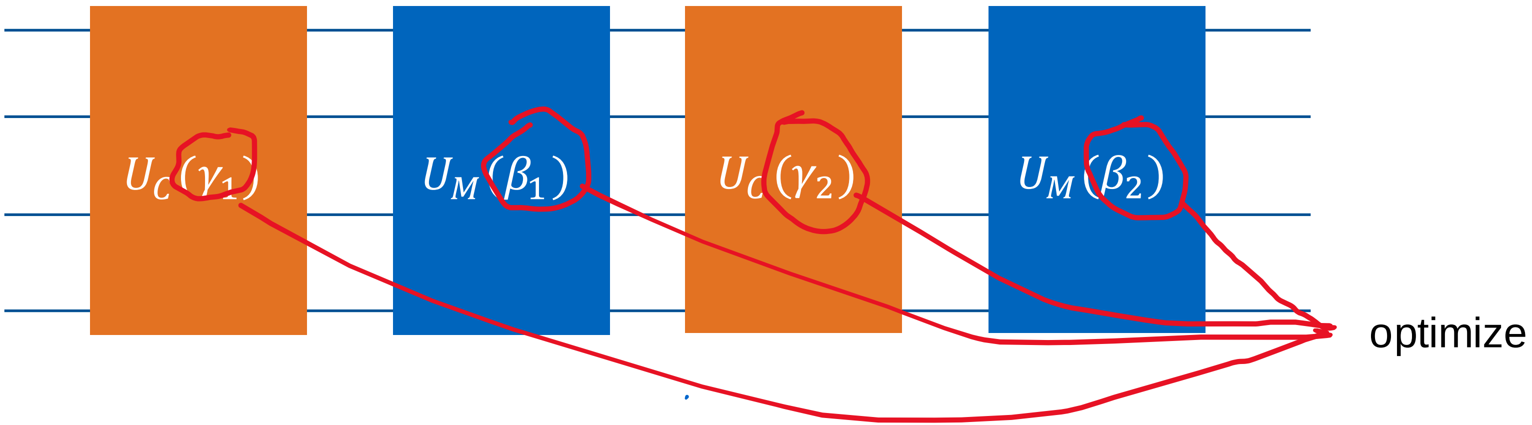
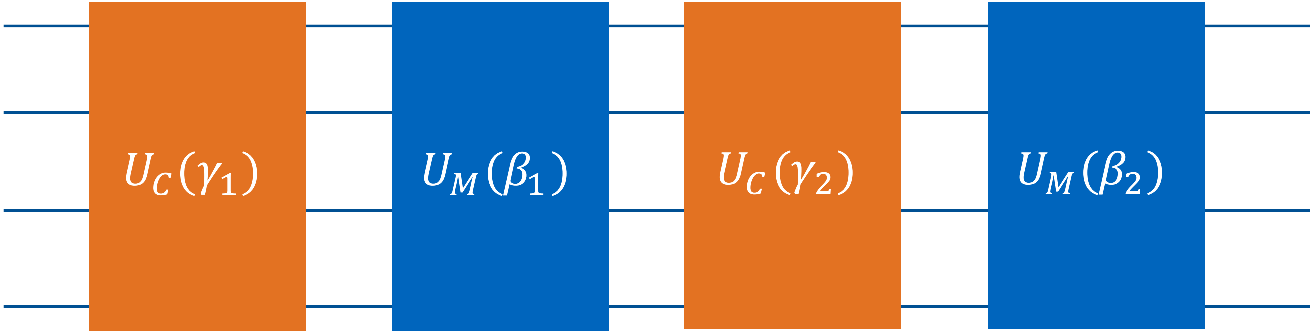


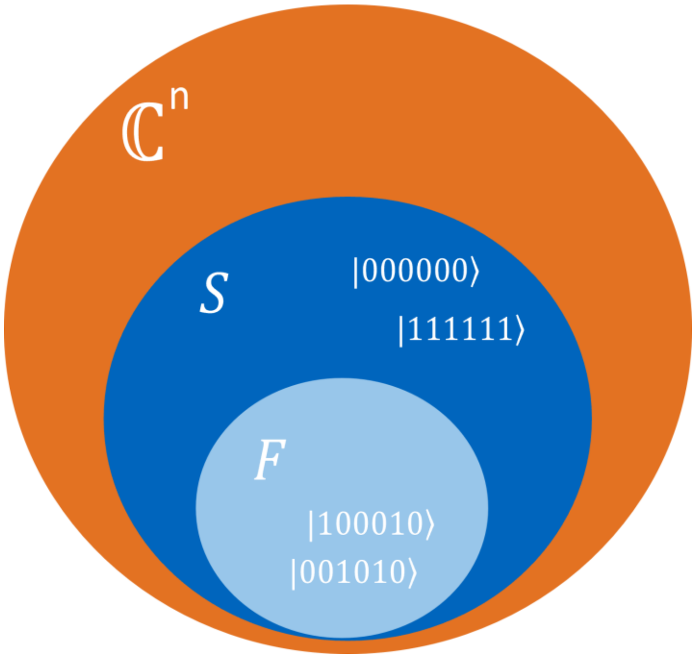
Quantum Alternating Operator Ansatz (QAOA)

$$H(t) = \left(1 - \frac{t}{T}\right) M + \frac{t}{T} C \qquad \text{for } t \in [0, T]$$

Enforces constraints



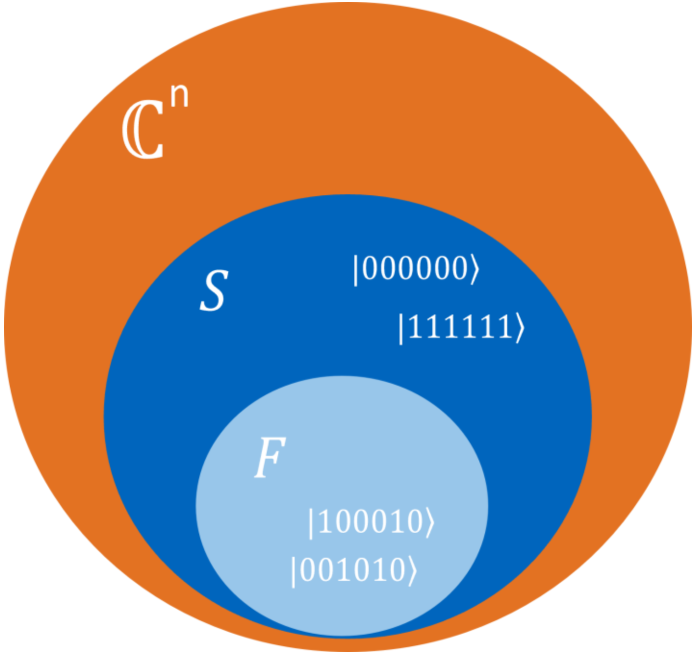
Solution subspaces



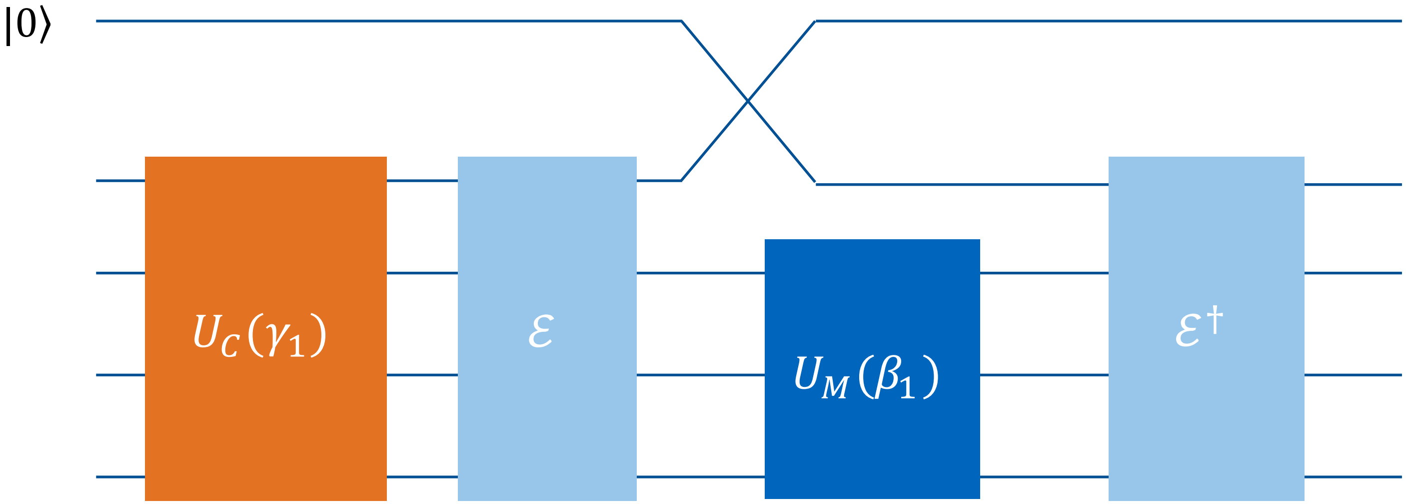
Solution subspaces

Idea: Use binary encoding for *F*.

- Encode $\mathbb{C}^n$ into $\mathbb{C}^k$, where $k < n$ and k is the number of feasible solutions

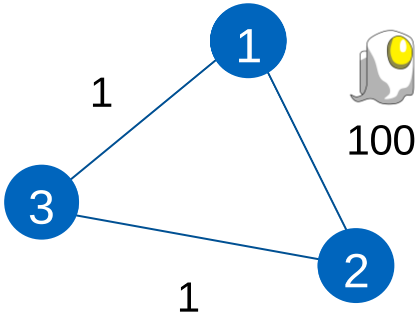


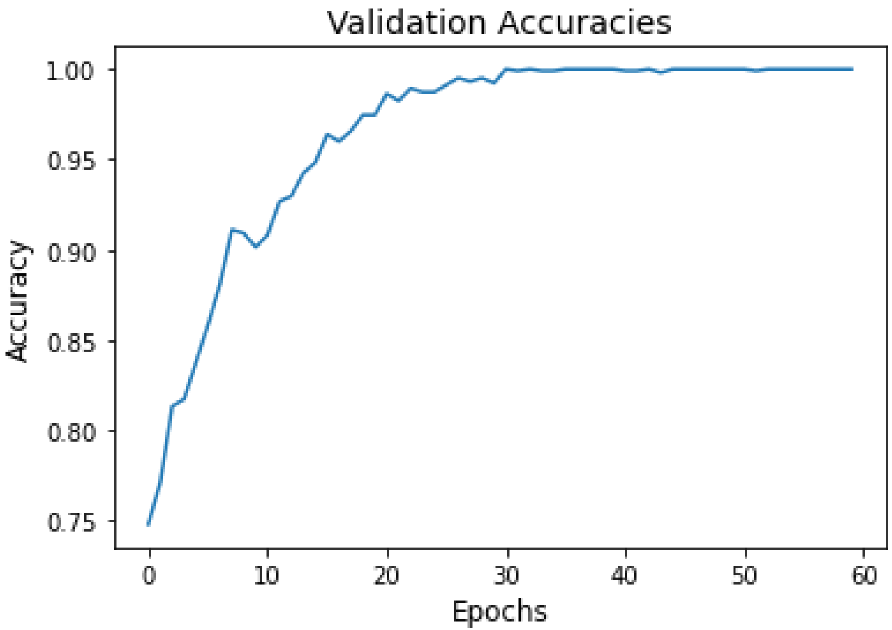
QAOA with autoencoders



Results

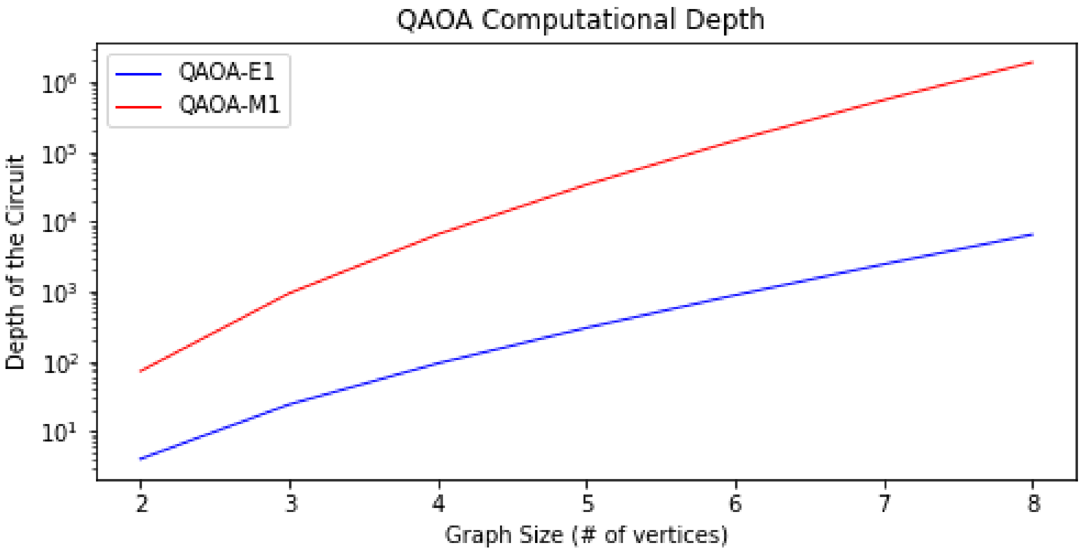
Tested on a toy model of the Travelling Salesman Problem





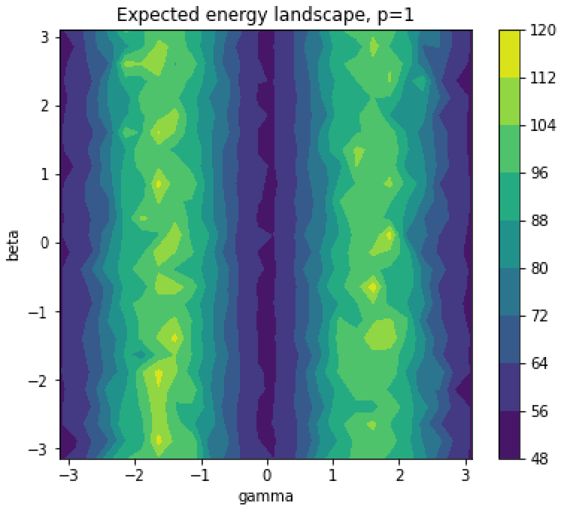
Results

Comparison with Quantum Alternating Operator Ansatz (QAOA-M)

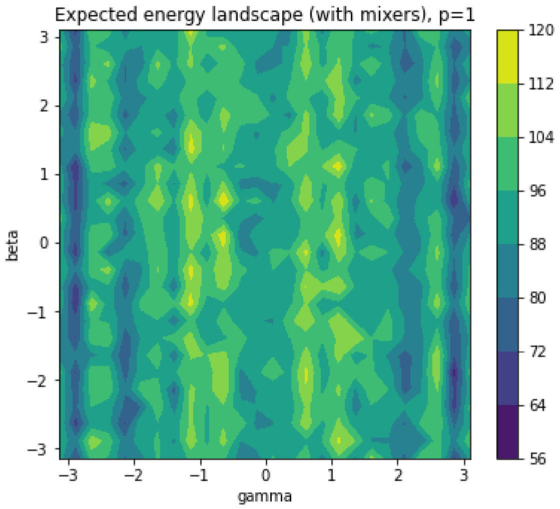


Results

QAOA-E



QAOA-M



Comparison with Quantum Alternating Operator Ansatz (QAOA-M)

Summary

- Autoencoders allow us to restrict search space to only feasible solutions
- Pros:
  - No need to find complicated mixer
  - Shallower circuit
  - Smoother optimization landscape
- Cons:
  - Need ancillary qubits (and number grows as number of QAOA steps grow)

Questions?