Quantum Gate Synthesis
- SQUANDER -

Balázs Menkó

Supervisor: Péter Rakyta
Eötvös Loránd University

Scientific Modelling Computer Laboratory
March 13, 2025

Variational Quantum Eigensolver
VQE

- hybrid quantum classical algorithm [1]
- approximate the E_{ground} of a system [2]
- parametrized quantum circuit
- iterative minimization based on classical method

Optimizer methods

- SQUANDER built-in optimizers (**gradient-based**)
  - ADAM - *Adaptive Moment Estimation*
  - BFGS - *Broyden–Fletcher–Goldfarb–Shanno*
  - Cosine strategy
  - Gradient descend
  - Gradient descend with parameter shift rule
- Other optimizers (**gradient-free**)
  - Nelder - Mead
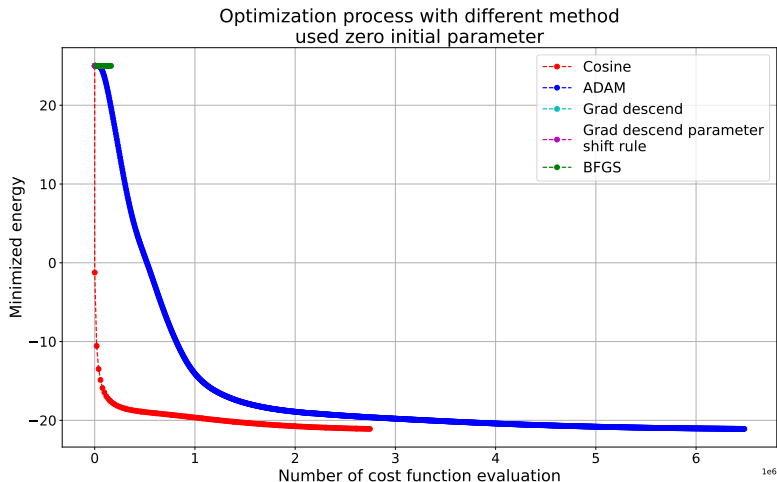 - Powell
  - Cobyla

Results of built-in methods

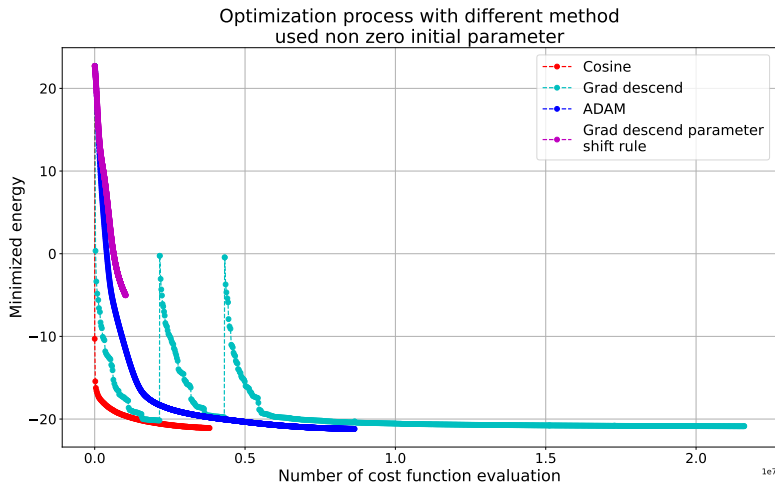Figure 1: Minimization of cost function with zero initial parameters.

Figure 2: Minimization of cost function with random initial parameters.

Further plans

- Run simulations for gradient-free methods.
- Compare the results with gradient-based algorithms.
- Change N_{layer} and N_{qubit} parameters to better results.

References

Jarrod R McClean, Jonathan Romero, Ryan Babbush, and Alán Aspuru-Guzik.
The theory of variational hybrid quantum-classical algorithms.
New Journal of Physics, 18(2):023023, 2016

Alberto Peruzzo, Jarrod McClean, Peter Shadbolt, Man-Hong Yung, Xiao-Qi Zhou,
Peter J Love, Alán Aspuru-Guzik, and Jeremy L O'brien.
A variational eigenvalue solver on a photonic quantum processor.
Nature communications, 5(1):4213, 2014