Quantum and classical methods for ground state optimisation in quantum many-body problems

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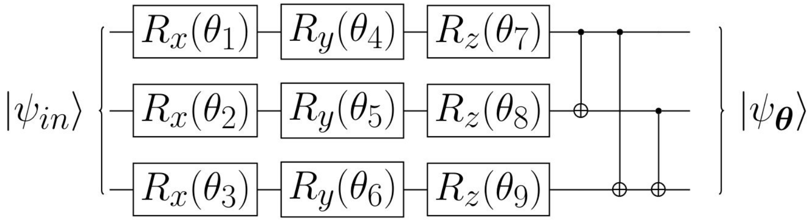
QMAI

(Variational) wavefunctions



- System of qubits, which are two level systems:
  - 00, 01, 10, 11
- Wavefunction is 'just' a vector of amplitudes

$$|\psi\rangle = \sum_{i=1}^{2^n} \alpha_i \, |\phi_i\rangle$$

- Variational wavefunction is some parameterised function to give some

$$|\psi(\theta)\rangle \approx |\psi\rangle$$

- We will compare two methods to create this variational wavefunction: a quantum circuit and a neural network

A. Peruzzo, J. McClean, P. Shadbolt, M.-H. Yung, X.-Q. Zhou, P. J. Love, A. Aspuru-Guzik, and J. L. O'Brien, "A variational eigenvalue solver on a photonic quantum processor," Nature Communications, vol. 5, July 2014.

G. Carleo and M. Troyer, "Solving the quantum many-body problem with artificial neural networks," Science, vol. 355, p. 602–606, Feb. 2017

Non-stabiliserness

- Non-stabiliserness, or *magic*, is a measure of how much ‘quantum resource’ is needed to perform operations on a wavefunction
- Given that the neural network is classical, does this limit its ability to find the ground state wavefunction of a quantum system?

- In short, no*. But see my poster for more details
  - In this work we explore each platform’s ability to find the ground state wavefunction with energy and magic equal to the analytic solution (available for small systems)