Extensions of Digital-Analog Quantum Computation

Mikel Garcia de Andoin
Álvaro Saiz, Pedro Pérez-Fernández, Lucas Lamata, Izaskun Oregi, Mikel Sanz

TECNALIA, Basque Research and Technology Alliance (BRTA), Astondo Bidea Edificio 700, 48160 Derio, Spain
EHU Quantum Center, University of the Basque Country UPV/EHU, Barrio Sarriena s/n, 48940 Leioa, Spain
mikel.garciadeandoin@tecnalia.com

Digital-analog quantum computing is a computational paradigm which employs an analog Hamiltonian resource together with single-qubit gates to reach universality [1]. This protocol benefits from the natural interaction Hamiltonian of quantum systems, as instead of trying to eliminate it enables us to use it as a resource. Additionally, it has been shown that this paradigm has inherent error mitigation capabilities [2]. Since it only requires the application of single qubit gates, it avoids the use of the noisier two qubit gates, providing a promising way of implementing algorithms in the NISQ era.

Regarding its applicability, it has already been shown useful for implementing ubiquitous quantum algorithms and solving various problems. Among them, the quantum Fourier Transform [3], the algorithm for solving a linear system of equations (HHL) [4] or a simulation of fermionic systems [5].

In this talk, we will focus on the theoretical background of this paradigm, providing tools for extending it to a large set of problems and systems. In our last work [6], we designed a new scheme which employs an arbitrary two-body source Hamiltonian, extending the experimental applicability of this computational paradigm to most quantum platforms. We showed that the simulation of an arbitrary two-body target Hamiltonian of n qubits requires $O(n^2)$ analog blocks with guaranteed positive times, providing a polynomial advantage compared to the previous scheme (Figure 1). Additionally, we proposed a classical strategy which combines a Bayesian optimization with a gradient descent method, improving the performance by ~55% for small systems measured in the Frobenius norm.

References

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Figure

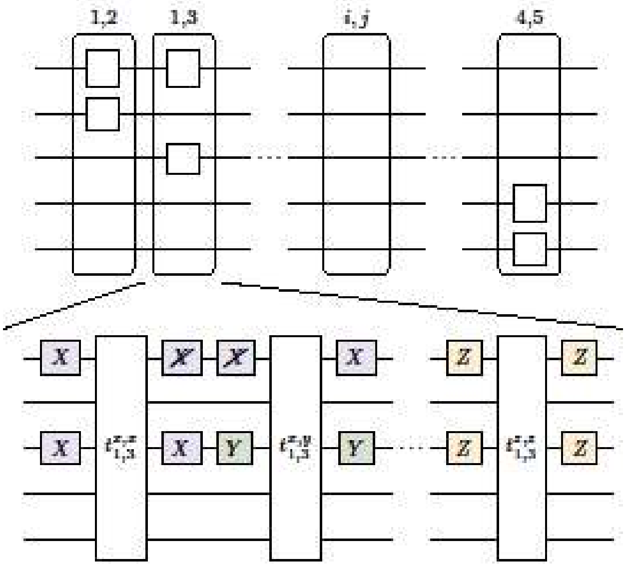

Figure 1: Example of a digital-Analog schedule for an arbitrary two body Hamiltonians composed of pairs of single qubit gates.