Quantum Metropolis Solver: A Quantum Walks Approach to Optimization Problems

Roberto Campos*

Departamento de Física Teórica, Universidad Complutense de Madrid. and
Quasar Science Resources, SL.

P. A. M. Casares†

Departamento de Física Teórica, Universidad Complutense de Madrid.

M. A. Martin-Delgado‡

Departamento de Física Teórica, Universidad Complutense de Madrid. and
CCS-Center for Computational Simulation,
Universidad Politécnica de Madrid.

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The efficient resolution of optimization problems is one of the key issues in today's industry. This task relies mainly on classical algorithms that present scalability problems and processing limitations. Quantum computing has emerged to challenge these types of problems. In this paper, we focus on the Metropolis-Hastings quantum algorithm that is based on quantum walks. We use this algorithm to build a quantum software tool called Quantum Metropolis Solver (QMS). We validate QMS with the N-Queen problem to show a potential quantum advantage in an example that can be easily extrapolated to an Artificial Intelligence domain. We carry out different simulations to validate the performance of QMS and its configuration.

* robecamp@ucm.es
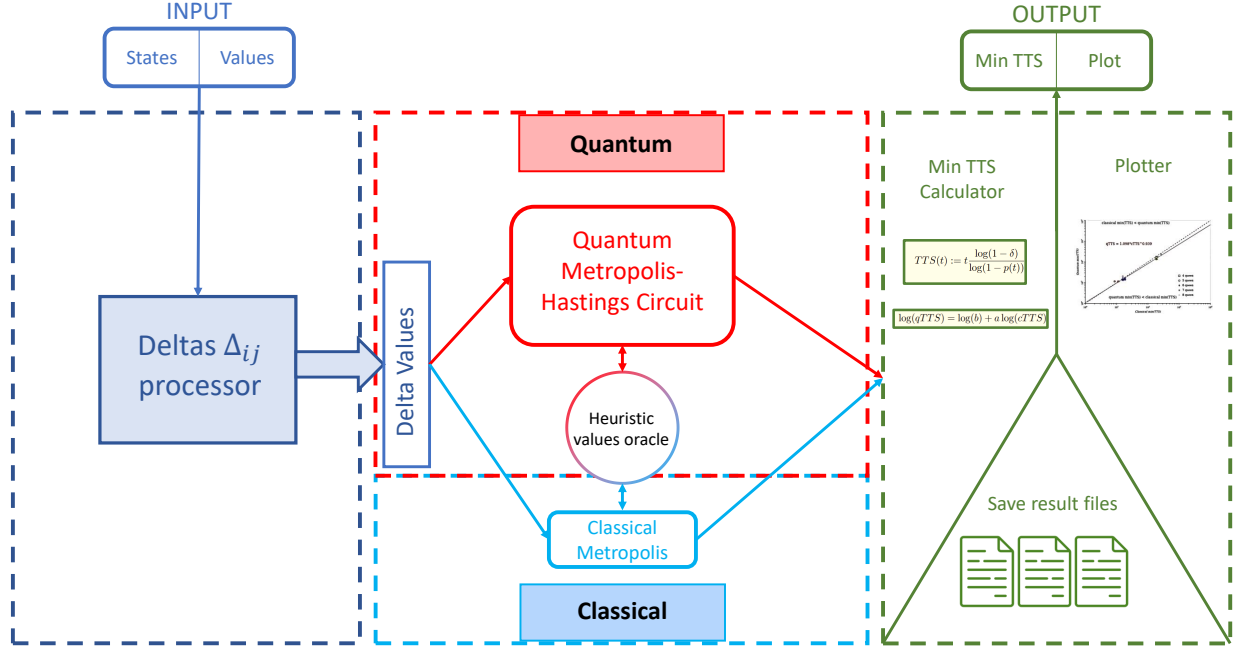
† pabloamo@ucm.es

‡ mardel@ucm.es

FIG. 1. Scheme of the QMS architecture. It receives a JSON file with a description of the possible states and the values associated with them. Then, the deltas between states (Δ_{ij}) are calculated and sent to the Quantum M-H module. This QM-H module constructs an initialization circuit to get the initial state x_t. Besides, the circuit of operator W is generated many times with a fixed parameter. Once the circuit is created, QM-H executes the circuit. The results obtained after execution using raw amplitudes are processed to get a plot with the evolution of the TTS, a numeric TTS value, or the probabilities. In parallel with the Quantum M-H execution, QMS has the option to execute a classical M-H, to compare both versions of the M-H algorithm. This classical M-H module has the same structure and connections with input and output as its quantum counterpart.