Driven Tabu Search: A Quantum Inherent Optimisation

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ABSTRACT

In Quantum Mechanics, a qubit is a quantum system in which the Boolean states 0 and 1 are represented by a pair of normalised and mutually orthogonal quantum states. The two states form a computational basis and any other state of the qubit can be written as a linear combination of $|0\rangle$ and $|1\rangle$: $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$, where α and β are probability amplitudes and can be complex numbers. A qubit can be in a superposition of both states at the same time. Multiple qubits can exhibit quantum entanglement - pairs are generated or interact in ways that the quantum state of each particle cannot be described independently of the state of the other(s) [2]. The IBM (International Business Machines Corporation) Quantum Experience (QX) allows us the possibility to connect to an IBM quantum processor via the IBM Cloud. We developed a driven quantum version of the Tabu search algorithm, which has been well understood for solving combinatorial or nonlinear problems [1]. The experiments were implemented in the Python programming language using the Quantum Information Software Kit (QISKit) - a software development kit (SDK) for working with the Open Quantum Assembly Language (OpenQASM) and the IBM QX. We use as backend the ibmqx5 (16-qubits), and both high performance

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computing and classical simulator. In a quantum-metaheuristic procedure, we challenge the quantum search space to be maximized, derived from the advantage of interacting quantum technologies with classical implementations. In a quantum combinatorial optimisation, an entanglement-metaheurisc can uncover optimal solutions and accelerate the optimisation process by using entangled states. Therefore, we conduct simulation-based experiments with two types of quantum initial populations. The sample solutions are composed by 16 qubits of combined pairs - with non replacement, and with replacement. Until we obtain the best solution, we build the neighborhood, evaluate the system and detect whether the algorithm falls in a local optimum. In those cases, we perform the entanglement between qubits if they are unequal; otherwise, we use superposition in the redundant qubit. This particular feature of enhanced-entanglement showed best solution in qubit 1 and qubit 3, and a system evaluation score of 60. An enhanced-superposition in qubit 1 presented an evaluation score of 28, and it was the best solution found. The quantum inherent optimisation allows us to highlight the best solution and algorithm performance according to the input combined set.

CCS CONCEPTS

• **Mathematics of computing** → **Tabu search**; • **Computer systems organization** → **Quantum computing**; • **Computing methodologies** → **Quantum mechanic simulation**;

KEYWORDS

Quantum tabu search; quantum computing benchmarks; combinatorial optimisation; quantum technologies; quantum-enhanced algorithms.

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