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(57) Abstract :
Abstract The present invention relates to a quantum computing system and method designed for efficiently solving complex optimization problems that are intractable for classical computing approaches. These optimization problems arise in various fields, including logistics, finance, drug discovery, energy management, and machine learning, where the exponential growth of the solution space limits the effectiveness of traditional algorithms. Leveraging quantum mechanical principles such as superposition, entanglement, and quantum interference, the invention utilizes advanced quantum algorithms, including the Quantum Approximate Optimization Algorithm (QAOA) and Variational Quantum Eigensolver (VQE), to explore multiple candidate solutions simultaneously and identify optimal or near-optimal results more efficiently. The system is specifically engineered to operate on Noisy Intermediate-Scale Quantum (NISQ) devices, incorporating noise-resilient quantum circuit designs that mitigate errors arising from qubit decoherence and imperfect gate operations. It features a hybrid quantum-classical computational framework that iteratively refines solutions by combining quantum processing with classical optimization techniques through adaptive feedback loops. This integration enhances solution accuracy and accelerates convergence while overcoming hardware limitations. Additionally, the invention introduces methods for dynamically decomposing large optimization problems into smaller subproblems, enabling scalable and modular quantum processing. It also includes efficient problem encoding techniques that transform real-world challenges into quantum-friendly formats such as Ising and Quadratic Unconstrained Binary Optimization (QUBO) models, optimizing resource utilization. Adaptive parameter optimization and advanced quantum resource management further improve computational efficiency and solution quality. The system's versatility allows application across a broad spectrum of industries requiring rapid and reliable decision-making. Overall, this invention represents a significant advancement in quantum computing by providing a practical, scalable, and robust platform for solving complex optimization problems, addressing key challenges in quantum hardware and algorithm design, and paving the way for enhanced real-world quantum applications.

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