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COMPARISON OF QUANTUM ALGORITHMS FOR QUADRATIC OPTIMIZATION

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Optimization problems appear widely in science and industry, yet their classical solutions often demand considerable computational resources. Quantum computing provides a promising framework for addressing such problems more efficiently by exploiting quantum superposition and entanglement [1]. In this work, we investigate several quantum gradient descent [2] approaches to find the minimum of a quadratic cost function. Performing the implementation through Amplitude encoding, we begin by a quantum gradient descent algorithm with a phase estimation-based method. To further enhance performance, we develop and test additional strategies, including linear combination of unitaries (LCUs) [3], the Sz.-Nagy dilation method [4], and a so-called unitary selection method, where the cost function is explicitly defined as a quadratic function. These methods are evaluated in terms of circuit depth, number of iterations, and accuracy. Our results show that the unitary selection outperforms phase estimation, LCUs provide a further improvement, and the Sz.-Nagy approach achieves the highest efficiency among all tested methods. This comparative study highlights the potential of pure quantum algorithms in solving real-world quadratic optimization problems.

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[3] Chakraborty, Shantanav. "Implementing any linear combination of unitaries on intermediate-term quantum computers." Quantum 8 (2024): 1496.

[4] Gaikwad, Akshay, Arvind, and Kavita Dorai. "Simulating open quantum dynamics on an NMR quantum processor using the Sz.-Nagy dilation algorithm." Physical Review A 106.2 (2022): 022424.

Presenting Author

Helarie Rose Medie Fah

Email

223153323@stu.ukzn.ac.za

Student or Postdoc?

PhD or DTech

Institute

University of KwaZulu Natal

Registered for the conference?

Yes

CHPC User

CHPC Research Programme

Primary author: Ms FAH , Helarie Rose Medie (UKZN)

Presenter: Ms FAH , Helarie Rose Medie (UKZN)

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