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Research and Study Intentions

Quantum computing is a very intriguing field. Ideally, I want to push our knowledge to bring quantum computing to the industrial sector. I see an abundance of opportunities to utilize quantum computations in chemistry simulations. However, to understand how we can push the boundaries of quantum computing, we need to understand our current limitations. Today's quantum processors are small and noisy. I want to study and understand how we can overcome the low number of qubits and the high exposure to noise.

In my 5th semester work, I researched best practices for solving logistics problems on classical computers and current results for quantum computers. As a result, I developed a QUBO formulation for the traveling salesmen problem and managed to implement it on Qiskit framework. I showed how unstably the ideally simulated VQE and QAOA algorithms work for 12 qubit size QUBO problem. Even without any noise they could not find a feasible solution.

In my last project I implemented the thermal relaxation noise model and used it to demonstrate how local Grover's operator can improve the quantum search algorithm by reducing its circuit depth and thus reducing the effect of noise on the outcome of the algorithm.

I intend to continue my study of the effects of noise on quantum circuits. My current tasks are to find a description of the influence of a simple noise model on the quantum search algorithm in terms of density matrix and test the hypothesis that the "reset" in the Shor's algorithm affects its exposure to noise.

The problem of high noise stands in the way of expanding the capabilities of quantum processors. That means that there is a need to use various optimizations: the local Grover operator, error-correcting codes, the use of additional qubits to reduce the depth of the circuit. My project has the potential of finding the most noise-resistant improvements to algorithms and new optimization techniques.

Ultimately, I am interested in the fields of quantum cryptography, quantum chemical simulations and quantum finite automata. My idea is to find an overlap between the potential of quantum computers and the quantum nature of chemical simulations. I already have experience with optimization algorithms, such as VQE and QAOA, which can be used in chemistry simulations. This summer I will be participating in 2022 Qiskit Global Summer School: Quantum Simulations and hope to gain as much experience as I can.

Yours truly,

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