**Quantum Computing**

**Final project**

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Grover's Algorithm

Find the right color order in the Master Mind game by using Grover's method. This method minimizes the number of guesses required by utilizing the quantum speedup that Grover's search provides.

Steps of doing it

1. To begin, initialize a register of qubits to represent every possible color sequence. In a game with m colors and n pins, n×log2(m) qubits are required. Utilizing Hadamard gates, generate a superposition of all conceivable sequences for every qubit.   
    for i in range(n\*log2(m)):

H qubit[i];

1. The right sequence is indicated by the oracle, a quantum circuit. When a sequence is entered, if it corresponds to the secret sequence, the amplitude is reversed. To do this, one must compare the guess with the secret sequence, and if they match, flip an auxiliary qubit.

if (guess == secret\_sequence):

Z flag\_qubit;

1. To increase the probability amplitude of the right sequence, apply the Grover diffusion operator. Applying Hadamard gates, X gates, a multi-controlled Z gate, and finally reversing the X and Hadamard gates are the steps involved in this process.

for i in range(n\*log2(m)):

H qubit[i];

X qubit[i];

H qubit[n\*log2(m)-1];

for i in range(n\*log2(m)-1):

X qubit[i];

H qubit[i];

1. Repeat the second and third steps approximately sqrt(N) times, where N = m^n. After the iterations, measure the qubits.

When It Operates:  
  
Sufficient Qubits and Gate Fidelity: This technique performs best when the quantum gates have high fidelity, guaranteeing precise operations, and there are sufficient qubits to describe the problem.  
reasonable Number of Colours and Pins: The issue size is achievable for existing quantum technology since Grover's approach is effective for a reasonable number of colors and pins.

When It Fails:  
  
The amount of qubits needed and the intricacy of the diffusion operators and oracle may be greater than what the state-of-the-art quantum computers can handle when dealing with many pins and colors.  
Decoherence and Error Rates: Grover's algorithm may function poorly in quantum systems with high error rates and decoherence, producing inaccurate results. Building an oracle that faithfully depicts the grading system can be difficult, particularly for version 1 of the game, which necessitates verifying the correct placements and colors.

Conclusion

With Grover's approach, we may use amplitude amplification and quantum parallelism to search the solution space more quickly than with classical methods, resulting in a considerable reduction in the number of guesses required to solve the Master Mind game. However, the development of error correction methods and quantum hardware is necessary for practical implementation.

References.

**Grover's algorithm** - <https://en.wikipedia.org/wiki/Grover%27s_algorithm>

<https://medium.com/visionary-hub/what-exactly-is-grovers-algorithm-a8f5dce1e1b3>

and used ChatGPT for better clarification.v