CS 530: High-Performance Computing
Seminar 2: Quantum Computing

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Contents

1 History of Quantum Computation & Information

2 Quantum Bits

- The bit and qubit is the most fundamental concept of information
- A classical bit has a state: either 0 or 1
- A quantum bit has a state: $|0\rangle, |1\rangle, \alpha|0\rangle + \beta|1\rangle$ for complex α, β such that $|\alpha|^2 + |\beta|^2 = 1$
- The state of a qubit is a unit vector in a two-dimensional complex vector space. In other words, qubits similar to are unit quarternions.
- $|0\rangle, |1\rangle$ are orthonormal and form computational basis states
- Can't directly measure α, β

- Example: a "quantim coin" with state $|+\rangle = \frac{1}{\sqrt{2}}|0\rangle + \frac{1}{\sqrt{2}}|1\rangle$ and 50-50 probability
- Can write $|\psi\rangle = e^{i\gamma}\left(\cos\left(\frac{\theta}{2}\right)|0\rangle + e^{i\phi}\sin\left(\frac{\theta}{2}\right)|0\rangle\right)$
- Because $e^{i\gamma}$ has no observable effect, we can reduced the above to $|\psi\rangle = \cos\left(\frac{\theta}{2}\right)|0\rangle + e^{i\phi}\sin\left(\frac{\theta}{2}\right)|0\rangle$
- Finished page 15 at Bloch sphere

3 Quantum Computation

3.1 Quantum Gates

3.2 Quantum Circuits

3.3 Examples

3.3.1 Bell States

3.3.2 Quantum Teleportation

4 Quantum Algorithms

4.1 Examples

4.1.1 The Quantum Fourier Transform

4.1.2 The Quantum Search Algorithm

5 Quantum Information

5.1 Quantum Cryptography

References

[1] Michael A Nielsen and Isaac L Chuang. *Quantum computation and quantum information*. Cambridge university press, 2010.