CSE490Q Lecture 08 Notes

Restricted Operations

- We need to come up with an instruction set for quantum computers
  - This gives us a way to convert an algorithm we want to run into steps that can be executed by a quantum computer.
- Can use a quantum "compiler" to translate logic to quantum instructions just like how a classical compiler translates code to machine instructions

Classical Universal Sets

- Any classical circuit can be implemented using a small set of universal logic gates
  - For example, { AND, OR, NOT } form a universal set for classical logic gates
- Universal sets are not unique

Quantum Universal Sets

- One universal set for quantum computers: { Any 1-qubit operation, CNOT }

Ion Traps

- Can do 1-qubit operations and CNOT, but can't be scaled up very well
- Other types of quantum computers often restrict the instruction set to a smaller set

Practical Quantum Instruction Sets

- May be implemented with just { H, T } (operations that will be introduced later)
- Errors accumulate rather than multiply
  - Error correction is handled by the compiler rather than developer

Theoretical Quantum Instruction Sets

- Instructions generally written like $[U]_{4,7}$, which means "apply U to qubits 4 and 7"
- Compiler is responsible for figuring out how to actually apply the operation

Mixed States

- Remember:
  - If interacting with a state and it's behaving like a distribution, it must be entangled. If it does not behave like a distribution, then it is not entangled with anything else.
- Need a way to distinguish between mixed states and pure states

Useful Quantum Operations

- Hadamard Gate
  - Arguably the most important basic quantum operation

- H = $\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 1\\ 1 & -1\end{bmatrix}$
- Turns $|0\rangle$ and $|1\rangle$ into an equal superposition and an equal superposition into a $|0\rangle$.