Summary of Key Concepts
Complexity of Algorithms

Week of February 4th, 2024

Resources

- QXQ YLC Week 15 Lab Notebook [STUDENT].ipynb
- QXQ YLC Week 15 Homework Notebook [STUDENT].ipynb

Key Terms

Key Term	Definition
Quantum Algorithm	A quantum circuit that performs a useful function.
Big-O	A method of determining the efficiency of an algorithm by calculating the worst case performance.
Oracle	An oracle is a part of an algorithm that can perform a specific computation “for free”. The tradeoff is that we can’t know how they do it.
Complexity Classes	A method of grouping together types of problems based on how fundamentally “difficult” they are.
Linear Search Algorithms	Linear search algorithms are a type of algorithm that check each individual element in a dataset to locate the correct answer.
Binary Search Algorithms	Binary search algorithms are a search algorithm that uses the structure of the dataset to find the element being searched for. A caveat of this is that the dataset must be sorted.

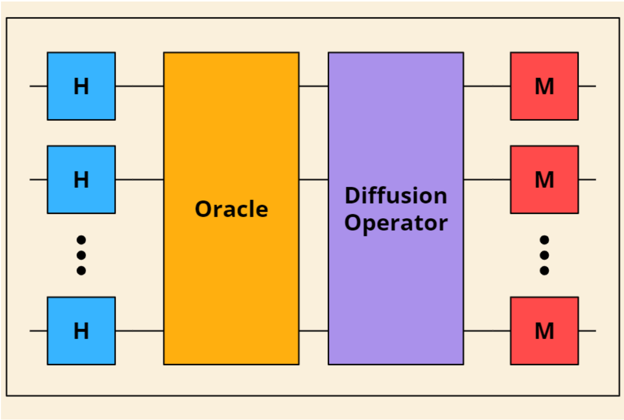
Lecture

Learning Objectives

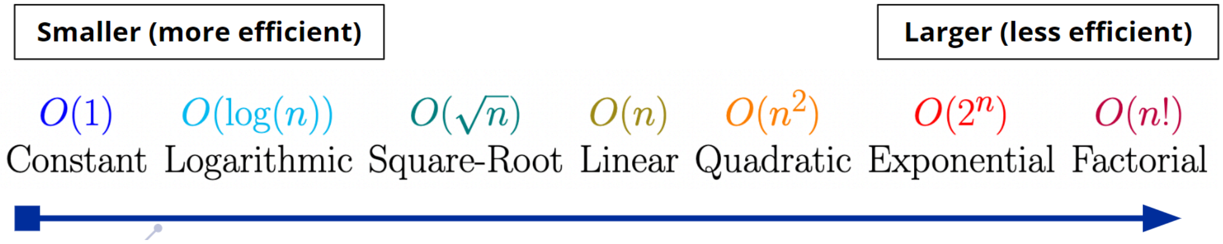
1. Recognize how quantum algorithms are designed.
2. Recognize what Big-O notation is and how to use it to compare algorithms.
3. Recognize what a complexity class is.

Key Ideas

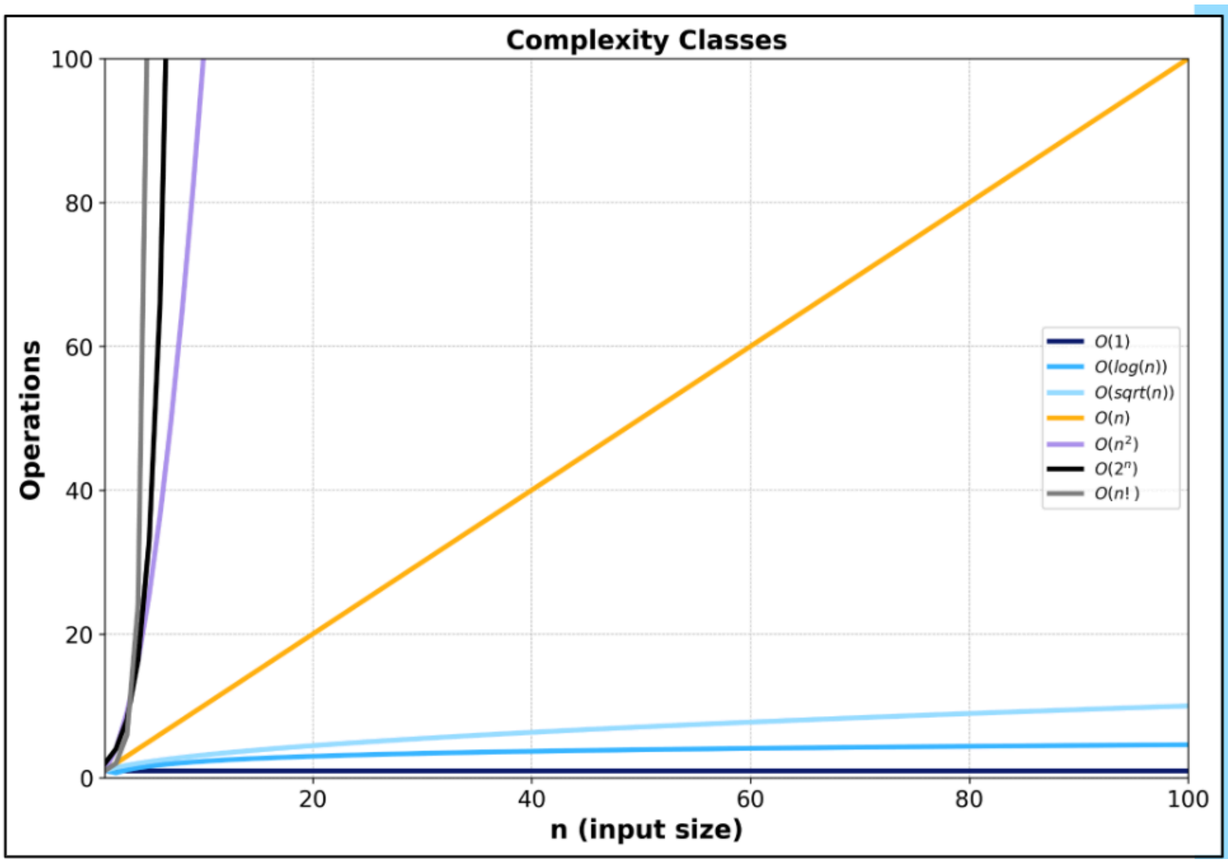
1. Quantum algorithms are simply quantum circuits that provide a useful function.



2. Designing a quantum algorithm can be done in three steps.
   a. First, understand the problem. Specifically, identify inputs and outputs.
   b. Second, convert to quantum states which can represent inputs and outputs.
   c. Finally, determine the correct quantum circuit that will successfully convert inputs to outputs.
      i. This step is often extremely difficult.
3. The goal of quantum algorithms (and quantum computing as a whole) is to solve problems more efficiently than would be possible using classical computers.
4. Big-O is a method of comparing algorithms by determining the efficiency based on worst-case calculation times. The smaller the Big-O measure, the more efficient the algorithm.



5. Complexity classes can be used to group together seemingly different problems based on how "difficult" they are.



6. Along with comparing the efficiency of algorithms, we will often want to compare the accuracy of algorithms.

Lab

Learning Objectives

1. Recognize how to compare algorithms using big-O notation.

2. Recognize the limits of classical search algorithms for unordered lists.

Key Ideas

1. For sorted data sets, binary search is more efficient than linear search.
    a. Big-O for binary search is $\log_2 N$.
    b. Big-O for linear search is N.