PRESIDENCY UNIVERSITY

(Established under the Presidency University Act, 2013 of the Karnataka Act 41 of 2013)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

CSE3080 QUANTUM COMPUTING

ORACLE CIRCUIT BUILDER

Mini - Project Report

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In partial fulfillment for the requirement of 6th Semester

CSE3080 QUANTUM COMPUTING

Under the Guidance of

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Academic Year 2022 - 2023

PRESIDENCY UNIVERSITY, BENGALURU - 560064

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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CERTIFICATE

Certified that the project work titled **'Oracle Circuit Builder'** is carried out by **R Bhargav(20201CAI0052), M Siddartha Reddy(20201CAI0066), Sathwik Chowdary(20201CAI0001), B Roshan Babu(20201CAI0002), K Teja(20201CAI0058)** who are bonafide students at Presidency University, Bengaluru, in partial fulfillment of the curriculum requirement of 6th Semester CSE3080 Quantum Computing Laboratory Mini Project during the academic year 2022**-2023**. It is certified that all corrections/suggestions indicated for the internal Assessment have been incorporated in the report deposited in the departmental library. The report has been approved as it satisfies the academic requirements in all respect laboratory mini-project work prescribed by the institution.

Signature of Faculty In-charge

Head of the Department
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<u>External Examination</u>

Name of Examiners	**Signature with date**
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ACKNOWLEDGEMENT

Any achievement, be it scholastic or otherwise does not depend solely on the individual efforts but on the guidance, encouragement and cooperation of intellectuals, elders and friends. A number of personalities, in their own capacities have helped me in carrying out this project work. I would like to take this opportunity to thank them all.

First and foremost, I would like to thank **Dr. Md. Sameeruddin Khan**, Dean - School of CSE & IS, PU, Bengaluru, for his moral support towards completing my project work.

I would like to thank **Dr. C. Kalaiarasan**, Associate Dean - CSE & IS, PU, Bengaluru, for his moral support towards completing my project work.

I would like to thank **Dr. Abdul Rahman**, Head of Department, Computer Science & Engineering, PU, Bengaluru, for his valuable suggestions and expert advice.

I deeply express my sincere gratitude to my guide **Dr. Jayakumar Vaithyashankar,** Department of CSE, PU, Bengaluru, for his able guidance, regular source of encouragement and assistance throughout this project.

I thank my Parents, and all the faculty members of the Department of Computer Science & Engineering for their constant support and encouragement.

Last, but not the least, I would like to thank my peers and friends who provided me with valuable suggestions to improve my project.

Abstract

This program aims to build an oracle circuit from a given problem, similar to the Phase Oracle class. The goal is to assess how the size of the circuits grows in relation to the size of the problem. By soliciting user input and providing clear output, the program ensures an intuitive understanding for users.

The program begins by prompting the user to input the problem they want to solve using the oracle circuit. This could be any problem that can be represented as a binary decision problem, such as searching for a specific item in a list or determining the satisfiability of a logical formula.

Next, the program processes the user's input and constructs the corresponding oracle circuit. An oracle circuit is a quantum circuit that encodes the problem-specific information into its structure, enabling quantum algorithms to efficiently solve the problem. The construction process considers the problem's characteristics and uses appropriate quantum gates and logical operations to create an efficient circuit representation.

As the problem's size increases, the program measures the growth of the oracle circuit in terms of the number of qubits and gates required. This assessment helps users understand the resources needed to solve larger instances of the problem using quantum computing techniques.

Finally, the program presents the circuit's size growth in a clear and comprehensible manner. It provides an output that shows the oracle circuit and the size of the oracle circuit, allowing users to visualize the growth pattern and comprehend the resources required for larger problem instances.

By combining user interaction, circuit construction, and growth assessment, this program facilitates understanding of the relationship between problem size and circuit complexity in quantum computing. This knowledge empowers users to make informed decisions when considering quantum algorithms for solving real-world problems efficiently.

Introduction

Welcome to the Oracle Circuit Builder program! This software is designed to help you understand how the size of oracle circuits grows with the size of a given problem. By building an oracle circuit from the problem you provide and assessing its complexity, you can gain insights into the resources required to solve larger instances of the problem using quantum computing techniques.

Quantum computing holds great potential for solving complex problems more efficiently than classical computers. Oracle circuits, in particular, play a crucial role in quantum algorithms by encoding problem-specific information into their structure. Understanding how the size of these circuits scales with problem size is essential for optimizing quantum computing resources and designing effective algorithms.

This program offers an intuitive interface that guides you through the process. You will be prompted to input the problem you want to solve using the oracle circuit. This problem could be any binary decision problem that can be represented in a computational form, such as searching, optimization, or logical reasoning.

Once you provide the problem description, the program will construct the corresponding oracle circuit. It leverages appropriate quantum gates and logical operations to create an efficient circuit representation that captures the essence of the problem. This step ensures that the constructed circuit provides an effective means for solving the problem using quantum algorithms.

After constructing the circuit, the program assesses its size growth with respect to the problem's size. By measuring the number of qubits and gates used by the circuit, it quantifies the resources required for solving larger instances of the problem. This analysis provides valuable insights into the scalability of quantum algorithms and helps you gauge the computational power needed for real-world problem-solving.

The program will then present the output in a clear and understandable format, displaying the size of the oracle circuit in terms of qubits and gates. This visual representation allows you to grasp the growth pattern and comprehend the relationship between problem size and circuit complexity.

By using the Oracle Circuit Builder program, you can explore the fascinating world of quantum computing, gain insights into the intricacies of oracle circuit construction, and understand the resource requirements for solving complex problems efficiently. Let's dive in and discover the growth patterns of oracle circuits together!

Problem Statement

Create a program that builds an oracle circuit from a problem (like the Phase Oracle class does). Assess how the size of your circuits grow with the size of the problem. Ask the user input and display the output in such a way that new user understands it.

Programming Code

```
from qiskit import QuantumCircuit, transpile, assemble, Aer, execute

# Function to build the oracle circuit
def build_oracle_circuit(target_number, number_of_qubits):

    # Create a quantum circuit with the specified number of qubits
    circuit = QuantumCircuit(number_of_qubits + 1)

    # Apply the X-gate to the target qubit
    circuit.x(number_of_qubits)
```

```
    # Apply the controlled-Z gates based on the target number
    for i in range(number_of_qubits):
        if (target_number & (1 << i)):
            circuit.cz(i, number_of_qubits)

    # Apply the X-gate to the target qubit again
    circuit.x(number_of_qubits)

    # Return the constructed circuit
    return circuit

# Ask the user for the target number and the number of qubits
target_number = int(input("Enter the target number to search for: "))
number_of_qubits = int(input("Enter the number of qubits: "))

# Build the oracle circuit
oracle_circuit = build_oracle_circuit(target_number, number_of_qubits)
```

 # Display the oracle circuit

print("Oracle Circuit:")

print(oracle_circuit)

 # Print the size of the oracle circuit

print("Size of the oracle circuit:", oracle_circuit.size())

OUTPUTS

```
Enter the target number to search for:  1100
Enter the number of qubits:  4

Oracle Circuit:

q_0: ────────────────

q_1: ────────────────

q_2: ──────■─────────
           │
q_3: ──────┼──■──────
     ┌───┐ │  │ ┌───┐
q_4: ┤ X ├─■──■─┤ X ├
     └───┘      └───┘
Size of the oracle circuit: 4
```

```
Enter the target number to search for:  11000111101010101
Enter the number of qubits:  5

Oracle Circuit:

q_0: ──────■─────────────
           │
q_1: ──────┼─────────────
           │
q_2: ──────┼──■──────────
           │  │
q_3: ──────┼──┼──────────
           │  │
q_4: ──────┼──┼──■───────
     ┌───┐ │  │  │ ┌───┐
q_5: ┤ X ├─■──■──■─┤ X ├
     └───┘         └───┘
Size of the oracle circuit: 5
```

Conclusion

The Oracle Circuit Builder program provides a valuable tool for understanding the relationship between problem size and circuit complexity in quantum computing. By constructing oracle circuits from user-provided problems and assessing their size growth, this program offers insights into the resources required for solving larger instances of problems using quantum algorithms.

Through the user-friendly interface, the program allows users to input their problem descriptions and constructs corresponding oracle circuits using appropriate quantum gates and logical operations. This ensures that the circuits effectively encode problem-specific information and serve as a foundation for solving the given problems using quantum computing techniques.

By measuring the number of qubits and gates used by the constructed circuits, the program quantifies the resources needed for scaling the problem size. This analysis provides a clear understanding of the circuit's complexity and highlights the computational power required for solving larger problem instances. Such insights are crucial for optimizing quantum computing resources and designing efficient algorithms.

The program's output presents the circuit size growth in a comprehensible manner, allowing users to visualize and interpret the relationship between problem size and circuit complexity. This visualization facilitates informed decision-making when considering quantum algorithms for solving real-world problems.

In conclusion, the Oracle Circuit Builder program empowers users to explore the scalability of quantum algorithms by assessing the size growth of oracle circuits. By understanding the resources required for larger problem instances, users can harness the potential of quantum computing more effectively and drive advancements in solving complex problems efficiently.

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