Task1

March 25, 2025

Task 1:Quantum Computing part

In this there are 2 subtask we have to perform

We will be using cirq library for implementation

We will start by importing cirq and numpy

[1]:
```
import cirq
import numpy as np
```

First Subtask

First create 5 qubits using LineQubit which will create 5 qubits ie q0, q1,q2,q3,q4

[2]:
```
qubits = [cirq.LineQubit(i) for i in range(5)]
```

Now we will first create a circuit and then append all the 5 qubits in the circuit by applying Hadamard gate to each qubit

[3]:
```
circuit = cirq.Circuit()

circuit.append([cirq.H(q) for q in qubits])
```

Now we have to apply controlled not (CNOT) on (0,1), (1,2), (2,3), (3,4)

[4]:
```
circuit.append([cirq.CNOT(qubits[i], qubits[i+1]) for i in range(4)])
```

Now we will swap q0 and q4 using SWAP gate

[5]:
```
circuit.append(cirq.SWAP(qubits[0], qubits[4]))
```

Now we have to rotate X any qubit lets say q1 by pi/2

[6]:
```
circuit.append(cirq.rx(np.pi/2)(qubits[1]))
```

Plot the circuit

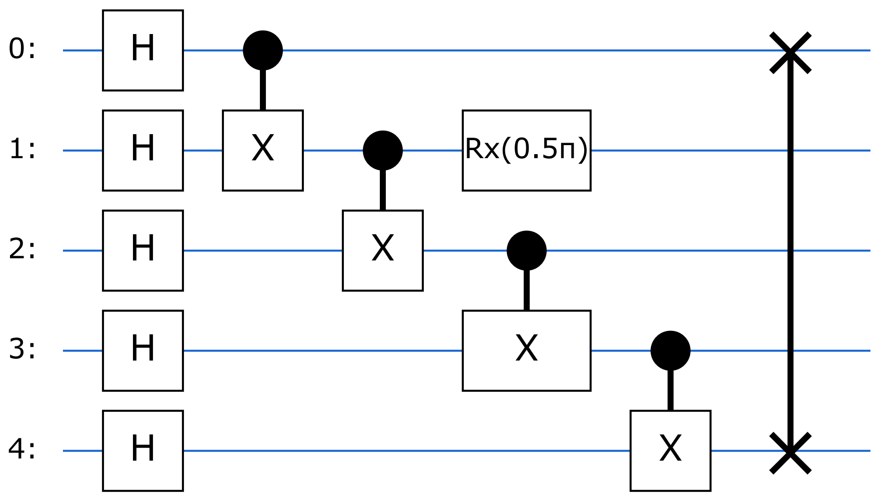
[7]:
```
print("Circuit diagram:")
print(circuit)
```

```
Circuit diagram:
0:   H  @           ×
```

```
1:   H  X  @  Rx(0.5 )

2:   H    X  @

3:   H      X      @

4:   H             X  ×
```

For better visualization we can use SVGcirciuts

[8]:
```
from cirq.contrib.svg import SVGCircuit
from IPython.display import display, SVG
display(SVGCircuit(circuit))
```



Second Subtask

We will be using cirq library for this task

In this task we will be using 5 qubits ie 4 normal qubits and one ancilla qubit

0.0.1 Role of ancilla qubit:

The ancilla qubit is used as a control mechanism that is used to check similarity between quantum states without measuring them If we measure the qubits it would collapse there superposition

0.1 Steps of the Swap Test

0.1.1 1. Initialize the Ancilla in |0

- The ancilla qubit starts in |**0** .

0.1.2 2. Apply Hadamard (H) on the Ancilla

- This puts the ancilla in an **equal superposition**:

$$|+\rangle = \frac{|0\rangle + |1\rangle}{\sqrt{2}}$$

0.1.3 3. Controlled SWAP (CSWAP) Operations

- The ancilla controls the **swap** of qubit pairs (`q1, q2`) and (`q3, q4`).
- If the ancilla is |**0** , nothing happens.
- If the ancilla is |**1** , the qubits swap.
- This **entangles the ancilla** with the similarity of the states.

0.1.4 4. Apply Hadamard Again to the Ancilla

- This transforms the ancilla back to a **new superposition** based on how much the states differ.

0.1.5 5. Measure the Ancilla

- **If the ancilla is |0** , the states are **similar** (higher probability).
- **If the ancilla is |1** , the states are **different** (higher probability).

Create 5 qubits

[9]:
```
qubits = [cirq.LineQubit(i) for i in range(5)]
q1,q2,q3,q4,ancilla = qubits
```

Create a empty circuit

[10]:
```
circuit = cirq.Circuit()
```

Apply hadmard gate to q1,q3,q4 and rotate q2 x by pi/3

[11]:
```
circuit.append(cirq.H(q1))
circuit.append(cirq.rx(np.pi/3)(q2))
circuit.append([cirq.H(q3), cirq.H(q4)])
```

Add the ancilla qubit to the circuit for swap test

[12]:
```
circuit.append(cirq.H(ancilla))
```

Use controlled swap gate (CSWAP) for q1,q2 and q3,q4

[13]:
```
circuit.append(cirq.CSWAP(ancilla, q1, q2))
circuit.append(cirq.CSWAP(ancilla, q3, q4))
```

Finalizing the swap test we have to apply H gate on ancilla

[14]:
```
circuit.append(cirq.H(ancilla))
```

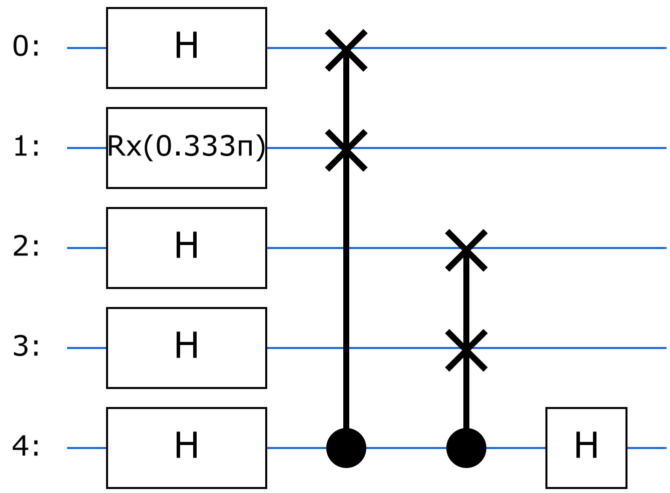
Print the circuit

[15]:
```
print("Circuit diagram:")
print(circuit)
```

```
Circuit diagram:
0:   H       ×

1:   Rx(0.333 )   ×

2:   H          ×

3:   H          ×

4:   H       @  @  H
```

For better visualization

[16]:
```
display(SVGCircuit(circuit))
```



[ ]:
```

```