QWorld Project

Shivalee RK Shah

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1 Class QuantumProgram

1.1 Class variables

1. Identity Matrix: starting point for read_unitary()
2. zero vector: starting point for read_state()

1.2 Methods to perform different operations

1.2.1 __init__ method

1. the number of qubits to start with are stored in no_of_qubits
2. the basis state according to number of qubits is stored in basis
3. all the qubits start with $|0\rangle$

1.2.2 basis state

this takes in decimal as parametre
this function returns a string of basis
e.g for 2 qubits it will return

```
00 for decimal 0
01 for decimal 1
10 for decimal 2
11 for decimal 3
```

1.2.3 vector_mat_mul

this function returns a product of vector and matrix

1.2.4 mat_mat_mul

this function returns a product of matrix and matrix

1.2.5 Tensor_vector

this function returns a tensor product of two vectors

1.2.6 Tensor_matrix

this function returns a tensor product of two matrices

1.3 Methods for single qubit gates

1.3.1 h-gate

- Syntax= .h(qubit_index)
- Parametre= qubit index
- this function tensors Identity matrix for all indices which does not match with parametre and tensors h gate matrix with the one that matches

1.3.2 x-gate

- Syntax= .x(qubit_index)
- Parametre= qubit index
- this function tensors Identity matrix for all indices which does not match with parametre and tensors x gate matrix with the one that matches

1.3.3 z-gate

- Syntax= .z(qubit_index)
- Parametre= qubit index
- this function tensors Identity matrix for all indices which does not match with parametre and tensors z gate matrix with the one that matches

1.3.4 rotation-gate

- Syntax= .rotation(angle,qubit_index)
- Parametre= angle in radians and qubit index
- this function tensors Identity matrix for all indices which does not match with parametre and tensors rotation matrix with the one that matches
- rotation matrix: $\begin{bmatrix} \cos\alpha & -\sin\alpha \\ \cos\alpha & \sin\alpha \end{bmatrix}$

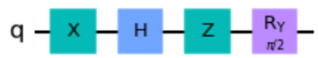
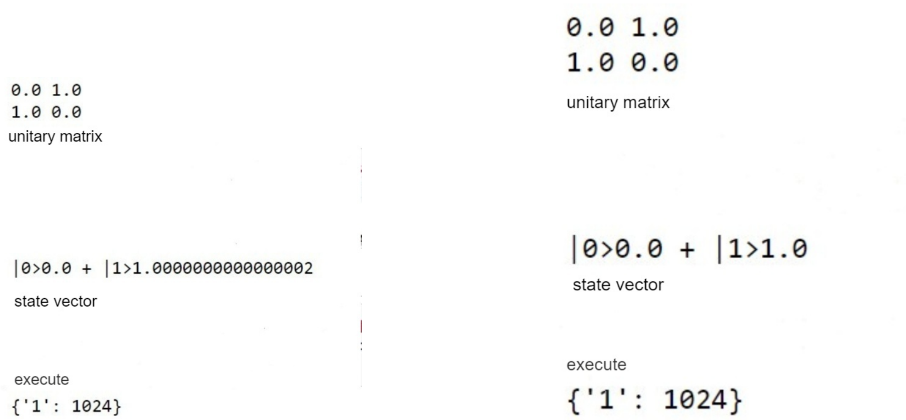


Figure 1: Circuit



(a) IBM simulator (b) My simulator

Figure 2: Comparison

1.4 Methods for 2 qubit gates

1.4.1 cx-gate

- Syntax= .cx(control, target)
- Parameter = control, target
- we know that in controlled not gate if control is 1 then x-gate is applied on target qubit
- we first create a 0 matrix of size $2^{no\_of\_qubits}$
- then according to working of cnot gate we construct the matrix

$$
\begin{aligned}
|00\rangle &\rightarrow |00\rangle \\
|01\rangle &\rightarrow |01\rangle \\
|10\rangle &\rightarrow |11\rangle \\
|11\rangle &\rightarrow |10\rangle
\end{aligned}
$$

1.4.2 cz-gate

- Syntax= .cz(control, target)
- Parameter = control, target
- in this we apply H gate then cx gate and then H gate

1.4.3 cr-gate

- Syntax= .cz(angle,control, target)
- Parameter = angle in radians, control, target
- here if control is 1 then rotation gate will be applied to the target bit
- then accordingly we construct the matrix

$$
\begin{aligned}
|00\rangle &\rightarrow |00\rangle \\
|01\rangle &\rightarrow |01\rangle \\
|10\rangle &\rightarrow \cos\alpha|10\rangle + \sin\alpha|11\rangle \\
|11\rangle &\rightarrow -\sin\alpha|10\rangle + \cos\alpha|11\rangle
\end{aligned}
$$

- then multiplies the matrix with previous unitary matrix

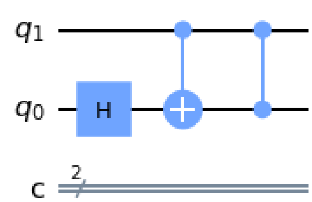
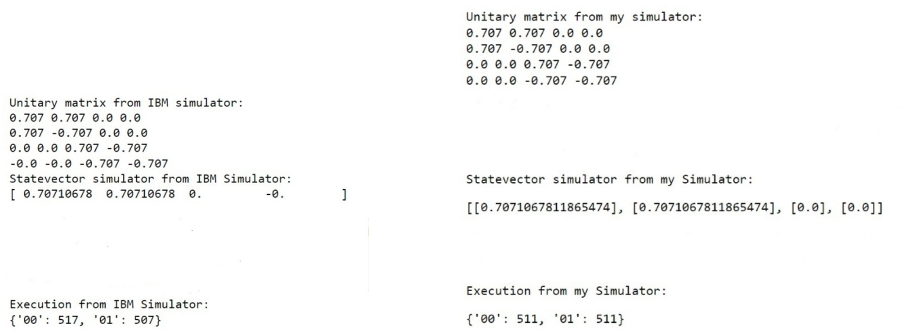


Figure 3: Circuit



(a) IBM simulator (b) My simulator

Figure 4: Comparison

1.5 Method for 3 qubit gate

ccx gate

- Syntax= .cx(control1, control2, target)
- Parameter = control1, control2, target
- it applies x-gate to target only when both control1 and control2 are 1
- according to its function matrix is made
- then multiplies the matrix with previous unitary matrix

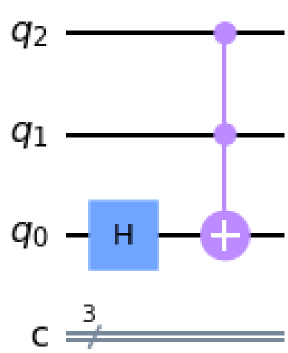
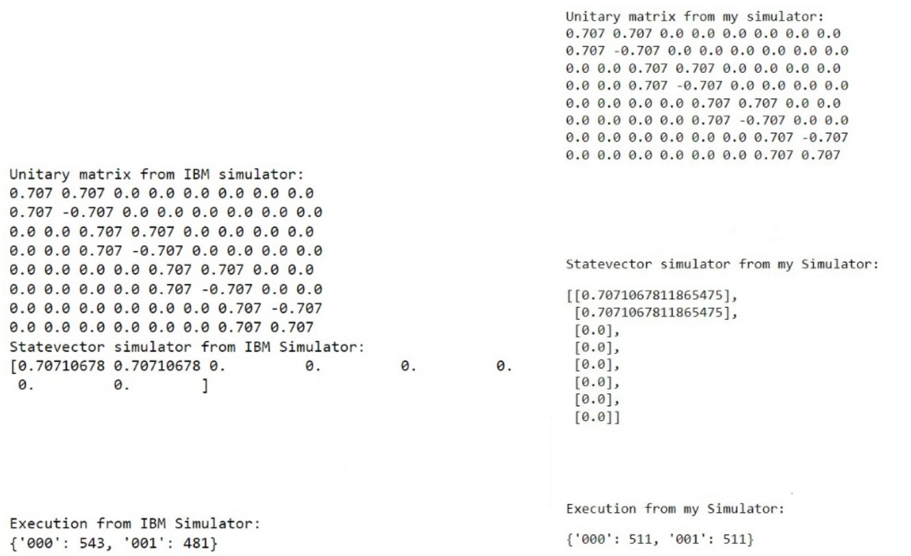


Figure 5: Circuit



(a) IBM simulator (b) My simulator

Figure 6: Comparison

1.6 Methods for simulating circuit

1.6.1 read_unitary()

Return a single unitary matrix (quantum operator) equivalant to all defined quantum operators until this point, i.e., the multiplication of all quantum operators in the defined order.
returns a matrix

1.6.2 read_state()

Return the current quantum state of circuit.
returns a column vector

1.6.3 observing_probabilities()

Return the probabilisties of observing the basis states if all qubits are measured at this moment.
returns a histogram showing basis state in x-axis and probabilities in y

1.6.4 execute()

Return the observed outcomes with their frequencies.
returns a dictionary