Qiskit Fall Fest at KU workshop 3

목차

1. Workshop 1 복습
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1. Workshop 1 복습

- Famous 6 single qubit state

$|0\rangle = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, $|1\rangle = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $|+\rangle = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$, $|-\rangle = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ -1 \end{bmatrix}$, $|+i\rangle = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ i \end{bmatrix}$, $|-i\rangle = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 \\ -i \end{bmatrix}$

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

$|-\rangle = \frac{1}{\sqrt{2}}(|0\rangle - |1\rangle)$

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

$|-i\rangle = \frac{1}{\sqrt{2}}(|0\rangle - i|1\rangle)$

- Single qubit gates
  - Pauli X

$|\psi\rangle$ — [X] — $X|\psi\rangle$ $\quad X = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$

ex) $X|0\rangle = |1\rangle$ $\quad X|+\rangle = |+\rangle$

$X|1\rangle = |0\rangle$ $\quad X|-\rangle = -|-\rangle$

- Pauli Y

$-[Y]-$ $\quad Y=\begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix} \quad Y=iXZ$

- Pauli Z

$-[Z]-$ $\quad Z=\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ ex) $Z|0\rangle=|0\rangle \quad Z|+\rangle=|-\rangle$

$Z|1\rangle=-|1\rangle \quad Z|-\rangle=|+\rangle$

- Hadamard

$-[H]-$ $\quad H=\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$ ex) $H|0\rangle=|+\rangle \quad H|+\rangle=|0\rangle$

$H|1\rangle=|-\rangle \quad H|-\rangle=|1\rangle$

- S gate

$-[S]-$ $\quad S=\begin{bmatrix} 1 & 0 \\ 0 & e^{i\frac{\pi}{2}} \end{bmatrix}$ ex) $S|0\rangle=|0\rangle$

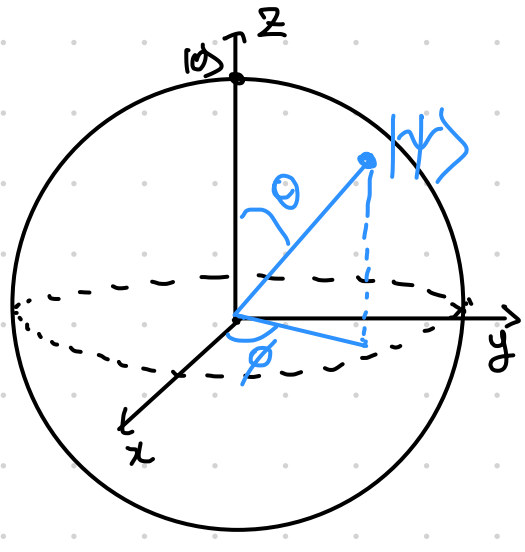
$S|1\rangle=e^{i\frac{\pi}{2}}|1\rangle$

- T gate

$-[T]-$ $\quad T=\begin{bmatrix} 1 & 0 \\ 0 & e^{i\frac{\pi}{4}} \end{bmatrix}$ ex) $T|0\rangle=|0\rangle$

$T|1\rangle=e^{i\frac{\pi}{4}}|1\rangle$

- Bloch sphere



$|\psi\rangle=\alpha|0\rangle+\beta|1\rangle$

$Pr[\text{measure}=|0\rangle]=|\alpha|^2$

$Pr[\text{measure}=|1\rangle]=|\beta|^2$

$\Rightarrow |\alpha|^2+|\beta|^2=1$

$|\psi\rangle=\cos\frac{\theta}{2}|0\rangle+e^{i\phi}\sin\frac{\theta}{2}|1\rangle$

- Tensor product

$$\begin{bmatrix} a \\ b \end{bmatrix} \otimes \begin{bmatrix} c \\ d \end{bmatrix} = \begin{bmatrix} a \begin{bmatrix} c \\ d \end{bmatrix} \\ b \begin{bmatrix} c \\ d \end{bmatrix} \end{bmatrix} = \begin{bmatrix} ac \\ ad \\ bc \\ bd \end{bmatrix}$$

$|0\rangle_A \otimes |0\rangle_B$ $|0\rangle_A |0\rangle_B$ $|0\rangle \otimes |0\rangle$ $|0\rangle|0\rangle$ $|00\rangle$ $|0\rangle$

$n=5$ $|3\rangle = |00|01\rangle$ $\because$ $3 = |01|_{(2)}$

$|31\rangle = |11111\rangle$ $\because$ $31 = |11111|_{(2)}$

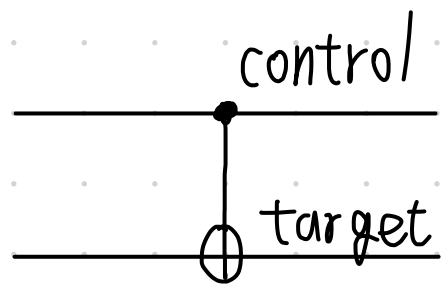
2. Gates

Pauli X, Y, Z, H, S, T

CNOT, Toffoli, swap, CZ

- CNOT (CX)

$$CNOT = \begin{bmatrix} 1 & & & \\ & 1 & & \\ & & & 1 \\ & & 1 & \end{bmatrix}$$

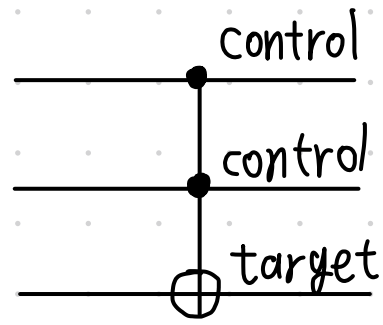


"control qubit이 $|1\rangle$일 때 target qubit에 X gate 가함"

Before		After	
control	Target	Control	Target
$\|0\rangle$	$\|0\rangle$	$\|0\rangle$	$\|0\rangle$
$\|0\rangle$	$\|1\rangle$	$\|0\rangle$	$\|1\rangle$
$\|1\rangle$	$\|0\rangle$	$\|1\rangle$	$\|1\rangle$
$\|1\rangle$	$\|1\rangle$	$\|1\rangle$	$\|0\rangle$

- Toffoli gate (CCX)

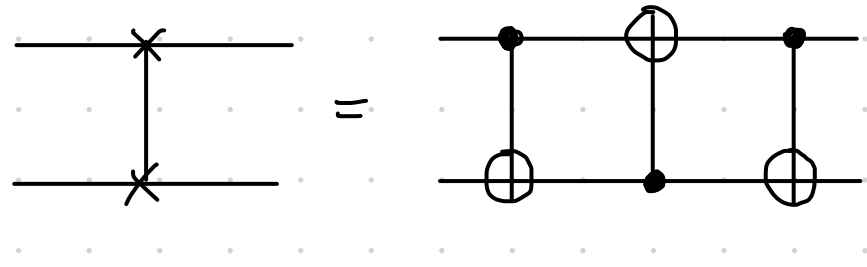
$$\begin{bmatrix} 1 & & & & & & & \\ & 1 & & & & & & \\ & & 1 & & & & & \\ & & & 1 & & & & \\ & & & & 1 & & & \\ & & & & & 1 & & \\ & & & & & & & 1 \\ & & & & & & 1 & \end{bmatrix}$$



"2개의 control qubits 가 모두 |1> 일 때,
target qubit 에 X gate를 가함"

- Swap

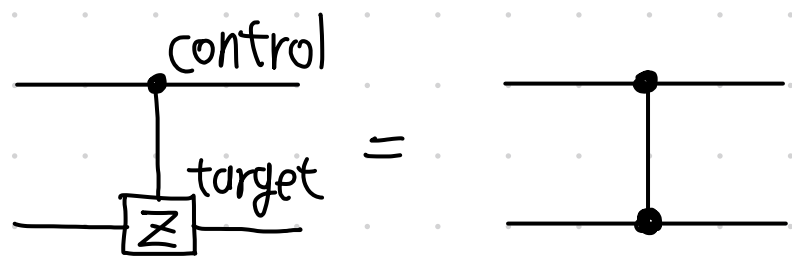
$$\begin{bmatrix} 1 & & & \\ & & 1 & \\ & 1 & & \\ & & & 1 \end{bmatrix}$$



"2개의 qubits의 양자상태를 서로 바꾼다"

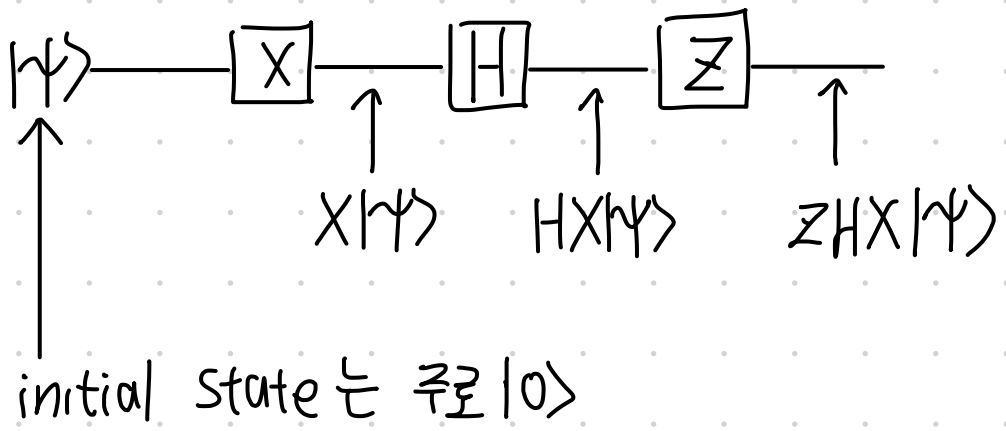
- CZ

$$\begin{bmatrix} 1 & & & \\ & 1 & & \\ & & 1 & \\ & & & -1 \end{bmatrix}$$



"control qubit이 |1>일때 target qubit에 Z gate 가함"

3. Quantum Circuit



initial state는 주로 |0⟩