Quantum Computing

Introduction

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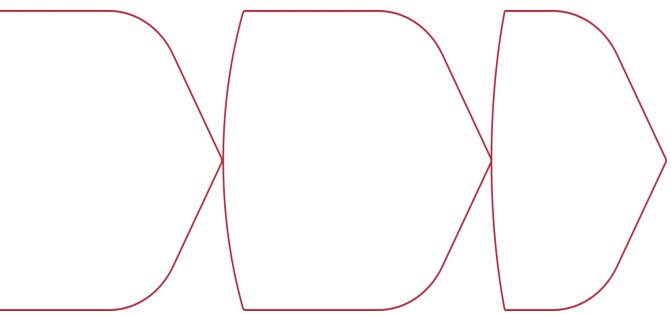


Agenda

Quantum Bits vs Classical Bits

Visualizing a Quantum Bit through Bloch Sphere

Bracket Notations

Quantum Gates

Disclaimer

"I am not an expert in quantum computing or quantum mechanics. My journey into this field began just a few months ago out of curiosity and a desire to explore how emerging ideas in quantum computing could enrich our teaching practices.
This talk reflects what I have learned so far, and I hope it sparks curiosity among you."

Quantum Bits vs Classical Bits

- The quantum bits take three values. These are:
  1. $|0\rangle$
  2. $|1\rangle$
  3. $\alpha|0\rangle + \beta|1\rangle$

  where α and β are coefficients taking values from complex number domain with $|\alpha|^2 + |\beta|^2 = 1$
- $|0\rangle$ and $|1\rangle$ are known as pure states and $\alpha|0\rangle + \beta|1\rangle$ is known as superimposed state.

- The classical bit in digital computing assumes only two values, 0 and 1.

The qubits and classical bits are used to encode information or represent states of the information system.

What is Superimposed state?

Pure States

- Result of a student appearing for an examination.
  1. PASS $|1\rangle$ *FAIL*$|0\rangle$
- The investment output arising out of a stock from a stock.
  1. GAIN $|1\rangle$ *LOSS*$|0\rangle$
- Today's climate condition
  1. Sunny $|1\rangle$ *Cloudy*$|0\rangle$

Superimposed States

- Result of a student appearing for an examination.

$$0.60\,|1\rangle + 0.4\,|0\rangle$$

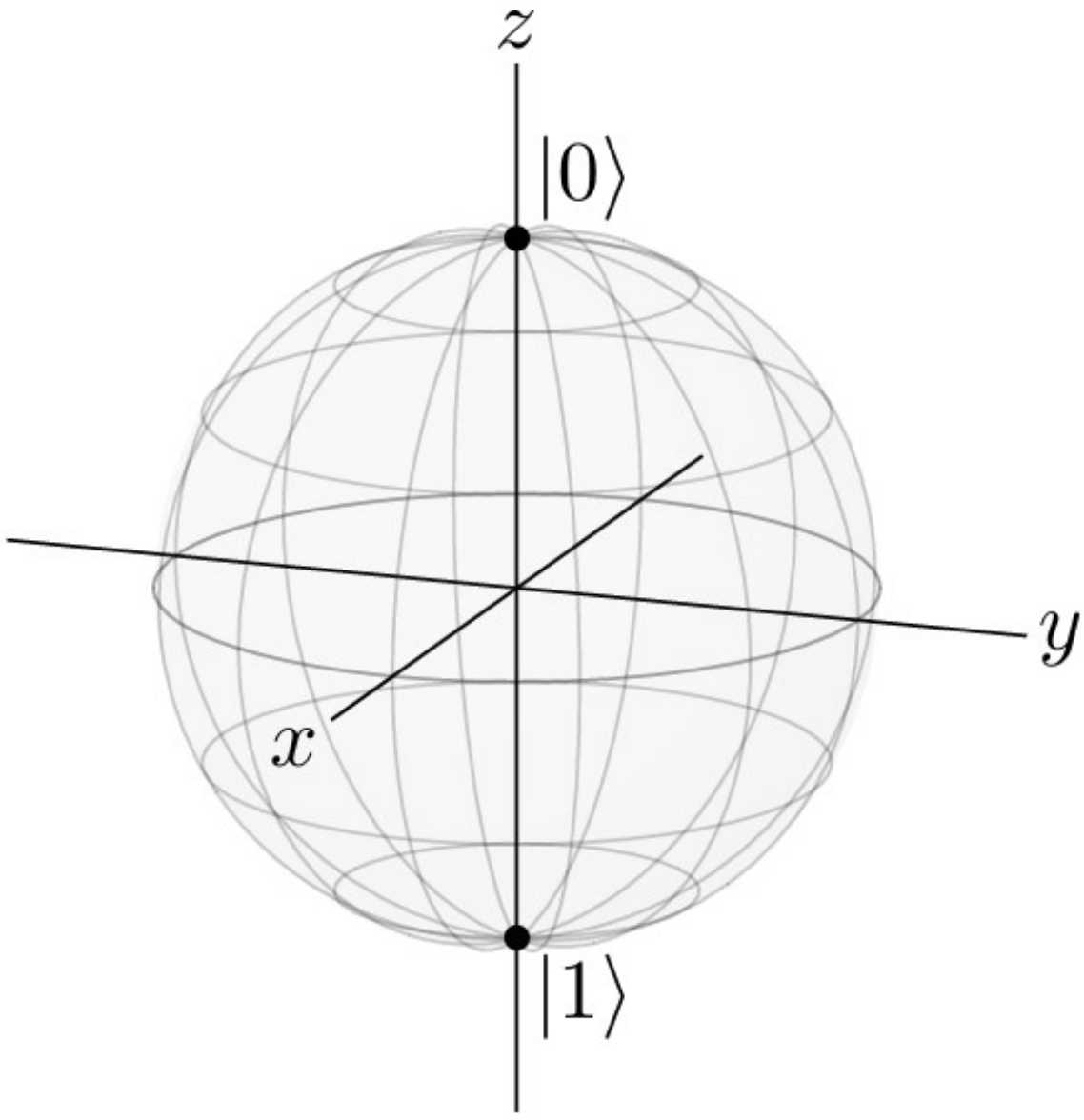
- The investment output arising out of a stock from a stock.

$$0.35\,|1\rangle + 0.65\,|0\rangle$$

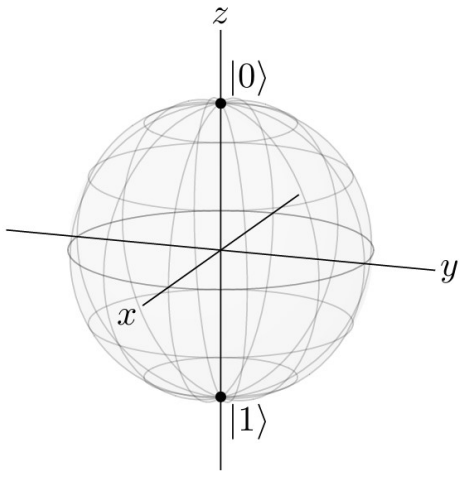
- Today's climate condition

$$0.25\,|1\rangle + 0.75\,|0\rangle$$

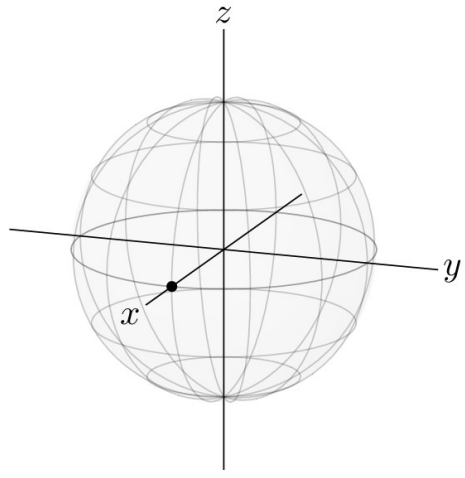
Visualizing a Quantum Bit through Bloch Sphere (Z-axis)



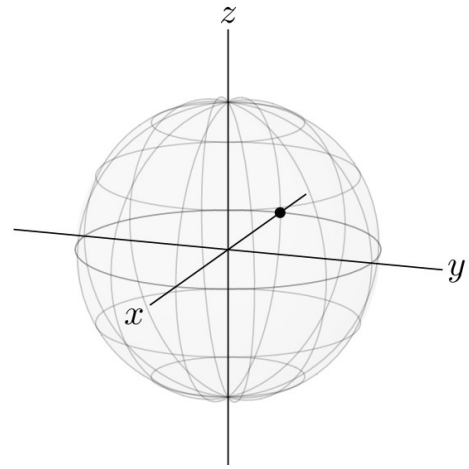
Visualizing a Quantum Bit through Bloch Sphere (X-axis)



$\|0\rangle$	(0,0,1)
$\|1\rangle$	(0,0,-1)

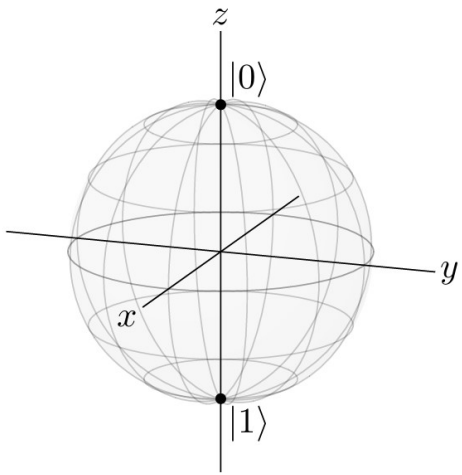


$\|+\rangle$	$\frac{1}{\sqrt{2}}(\|0\rangle + \|1\rangle)$
$\|+\rangle$	(1,0,0)

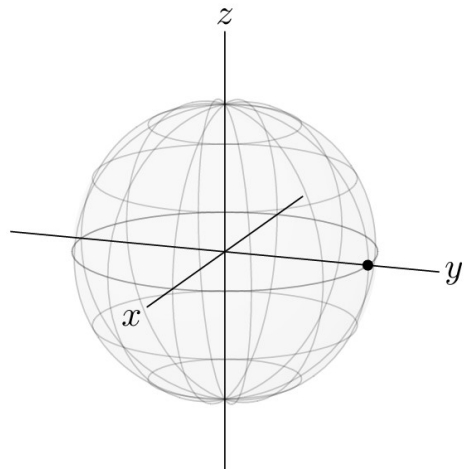


$\|-\rangle$	$\frac{1}{\sqrt{2}}(\|0\rangle - \|1\rangle)$
$\|-\rangle$	(-1,0,0)

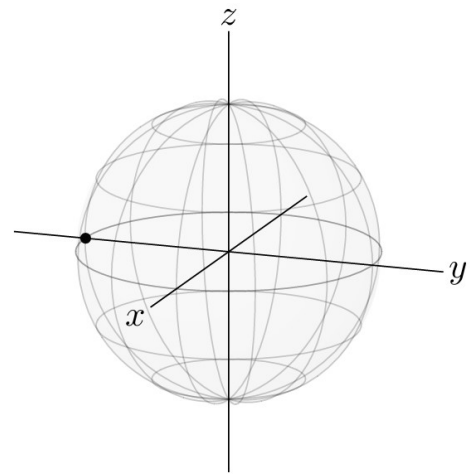
Visualizing a Quantum Bit through Bloch Sphere (Y-axis)



$\|0\rangle$	(0,0,1)
$\|1\rangle$	(0,0,-1)

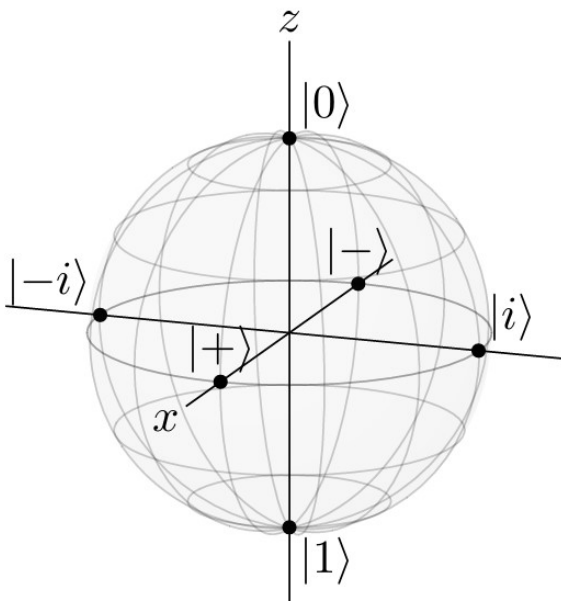


$\|i\rangle$	$\frac{1}{\sqrt{2}}(\|0\rangle + i\|1\rangle)$
$\|i\rangle$	(0,1,0)

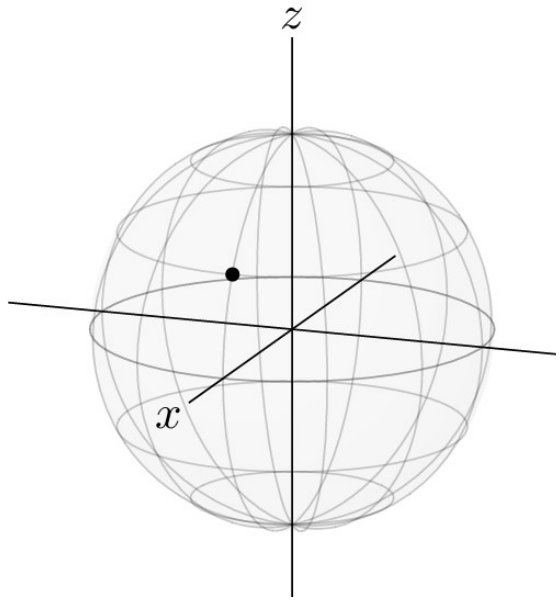


$\|-i\rangle$	$\frac{1}{\sqrt{2}}(\|0\rangle - i\|1\rangle)$
$\|-i\rangle$	(0,-1,0)

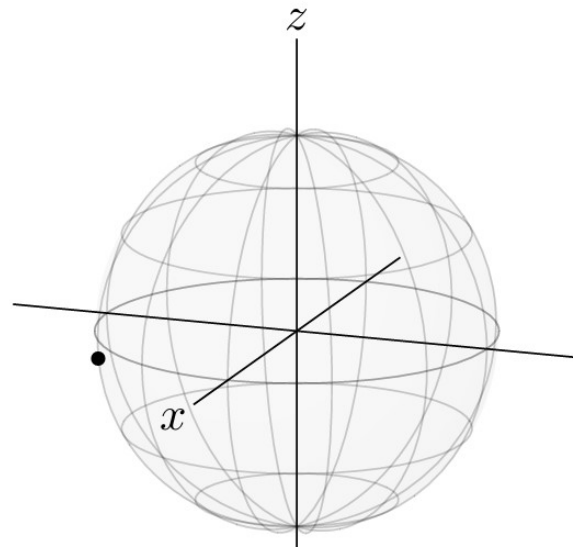
A Quantum bit can be anywhere on Bloch Sphere



$\frac{\sqrt{3}}{2}|0\rangle + \frac{1}{2}|1\rangle$



$\frac{2}{3}|0\rangle + \frac{1-2i}{3}|1\rangle$



A qubit can be any point on the Bloch sphere.

Bracket Notations
Part-I
Arvind W Kiwelekar