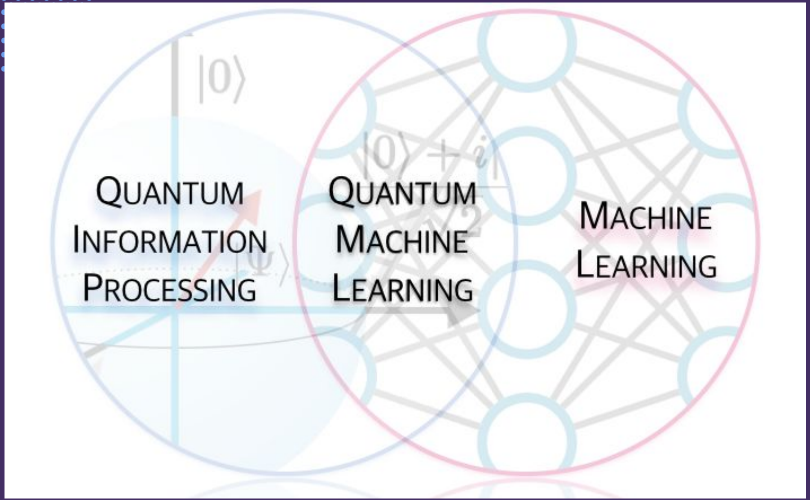
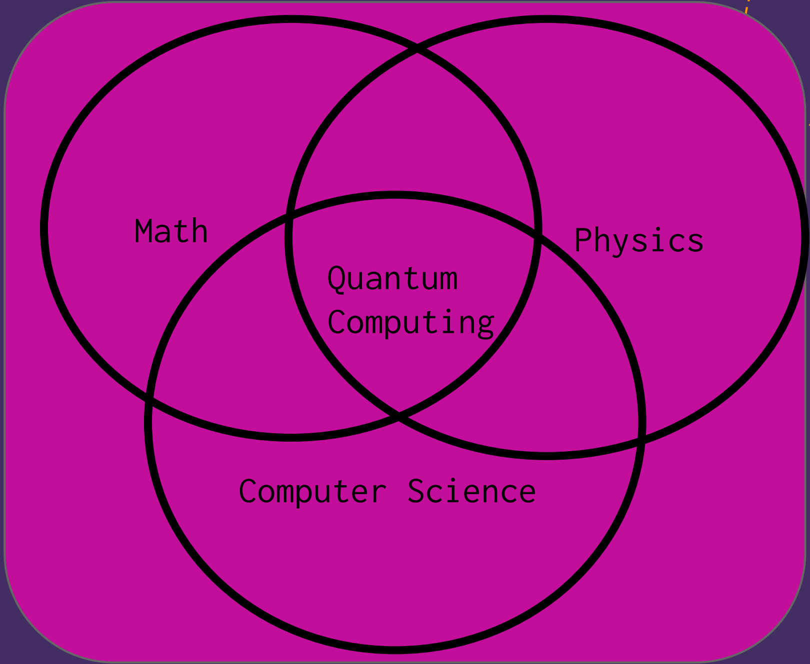
Quantum AI Algorithms Introduction





Intersection of 3 Fields

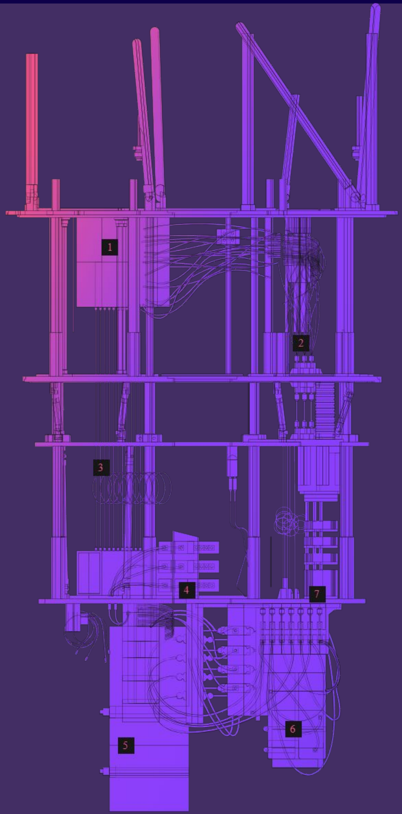
Background on Classical Computers

What is a Classical Computer?

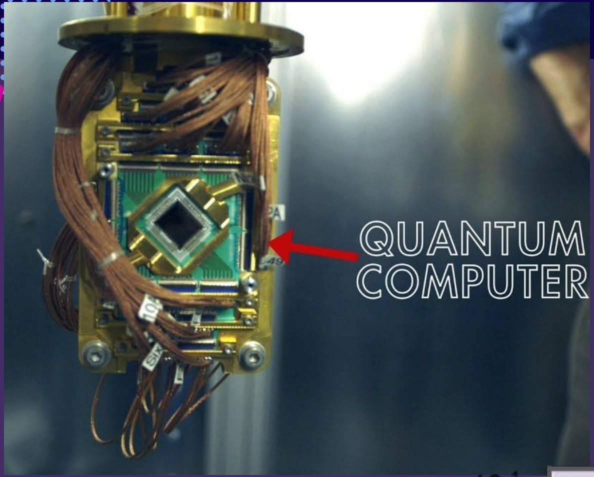
- Physical input (Ex : keyboard, mouse) → binary info
  - Binary computing
  - Reads bits - 0s and 1s
- CPU (Computer chip) → Modules → Logic gates → Transistors (processor)
  - 4 main functions to process data
    - **Fetches** instruction from memory, **decodes** assembly code instructions into binary instructions, **executes** calc with ALU, **output** data written to memory
  - Module - collection of circuits
  - Logic gates - tiny computers inside computer
- Memory (RAM)
  - Stores data being processed by CPU
- Output
  - Converts info to physical output (Ex : laptop, robot)
- Only classical algos work

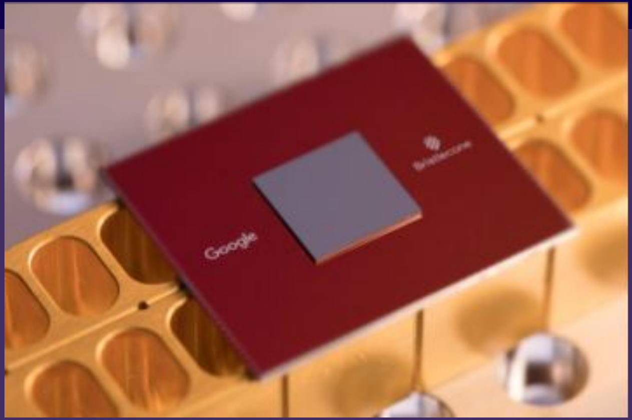
Quantum Computing Fundamentals - Intro to Quantum Mechanics Basics

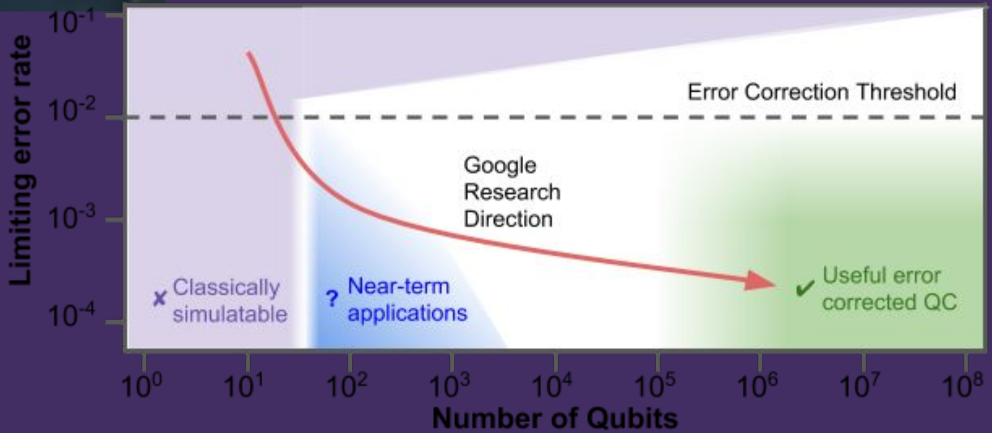
Inside a Quantum Computer



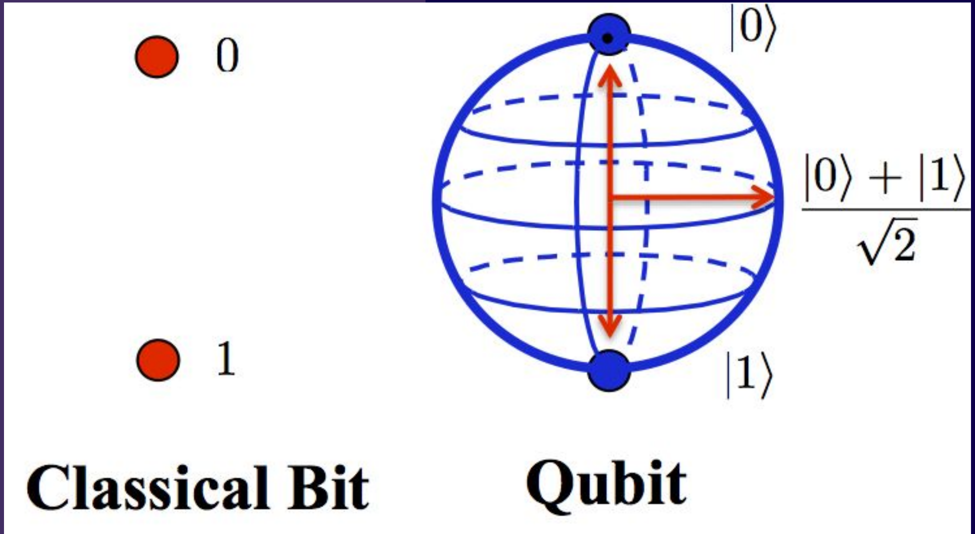
Inside a Quantum Computer







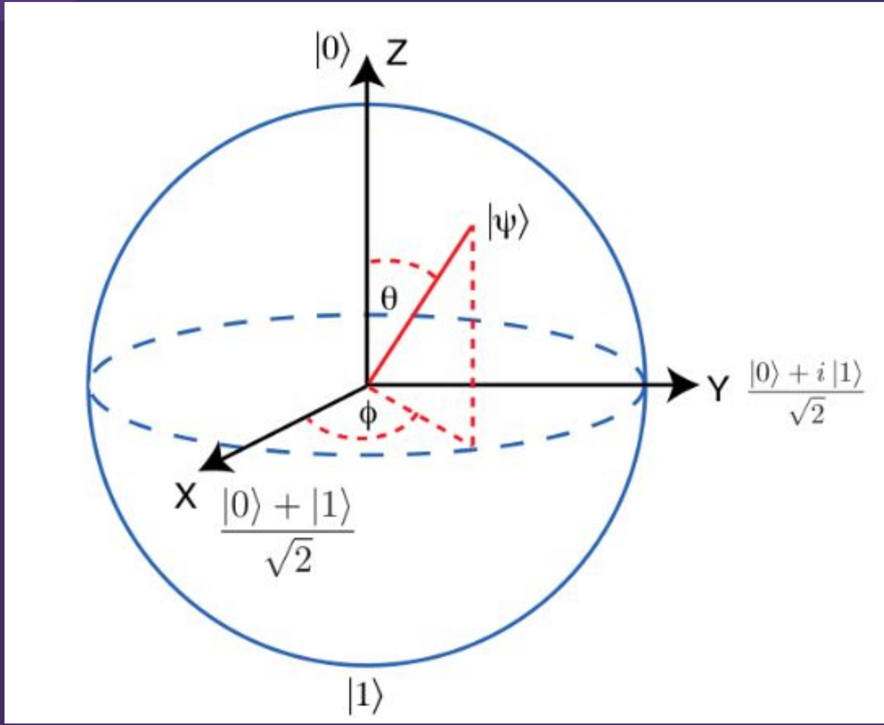
Bit System



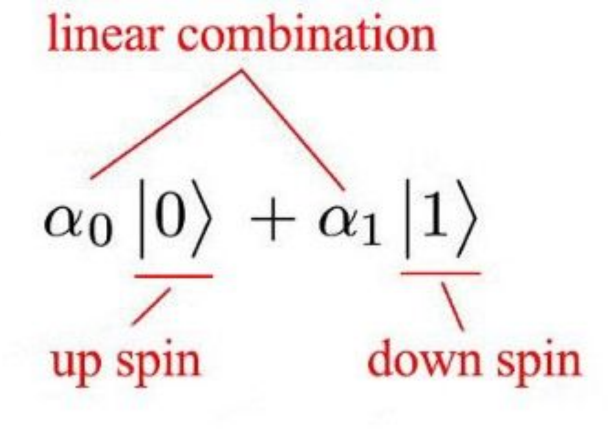
0
1
Classical Bit
$|0\rangle$
$\frac{|0\rangle + |1\rangle}{\sqrt{2}}$
$|1\rangle$
Qubit

Superposition

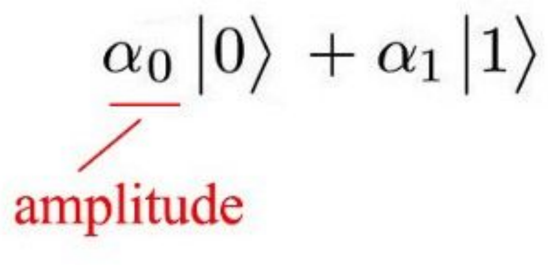
- Spin of particle is in superposition of states (Qubit can be in any proportion of both states at once)
    - Qubit's state = combination along all 3 axes
        - Changing probabilities through logic gates
        - **<u>In multiple states simultaneously BUT once measured → exists in only 1 state</u>**
- Able to analyze more poss than classical comp at one instance of time



$|0\rangle$ Z
$|\psi\rangle$
θ
ϕ
Y $\frac{|0\rangle + i\,|1\rangle}{\sqrt{2}}$
X $\frac{|0\rangle + |1\rangle}{\sqrt{2}}$
$|1\rangle$



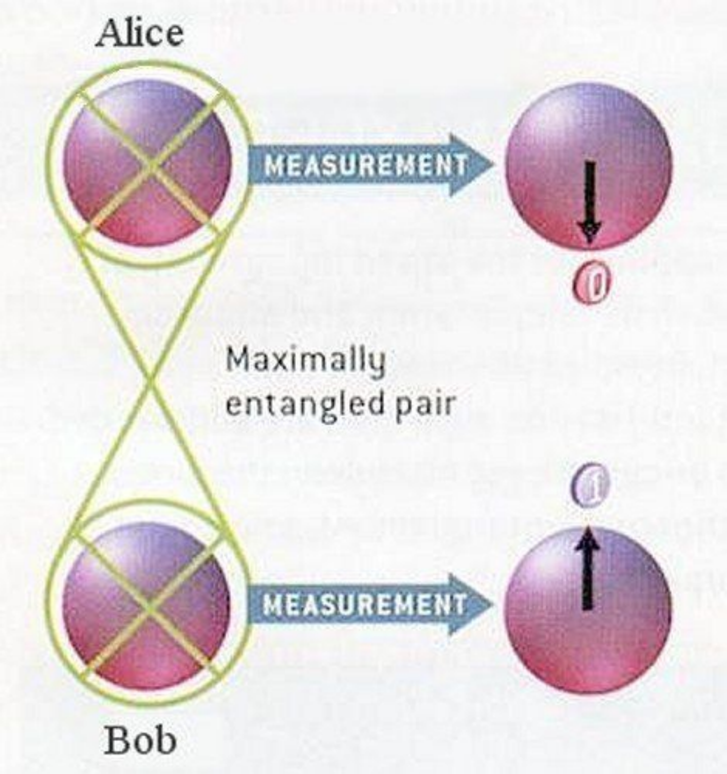
linear combination
$\alpha_0 \, |0\rangle + \alpha_1 \, |1\rangle$
up spin
down spin

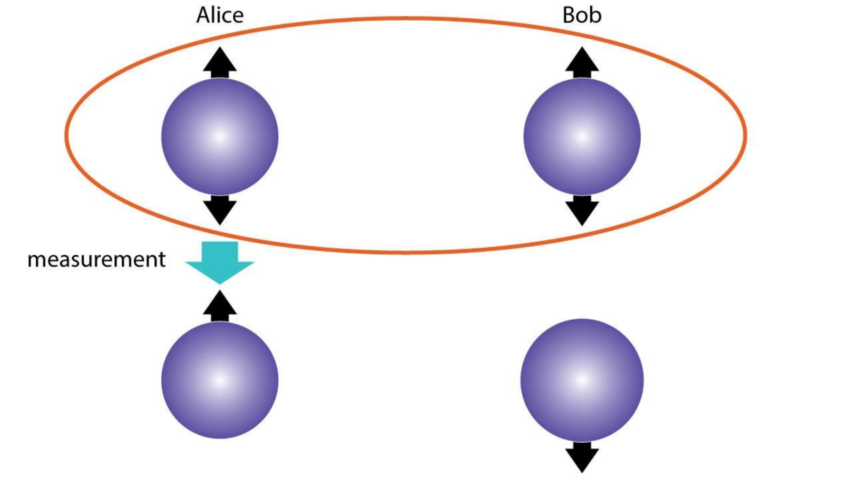


$\alpha_0 \, |0\rangle + \alpha_1 \, |1\rangle$
amplitude

Entanglement

- Pair of particles remain “connected” even when very far from each other
  - Actions affect each other
- Ex : laser beam fired through medium (crystal) will cause photons to be entangled
- Benefit - innovations over long dist comm (preserve quantum state)
  - Ex - teleporting humans


Alice
MEASUREMENT
0
Maximally
entangled pair
1
MEASUREMENT
Bob


Alice
Bob
measurement

History of Quantum

Einstein

- Didn't believe in entanglement and quantum computing properties
  - Believed entanglement didn't exist
- "Spooky Action At A Distance" - published with student in Princeton

Bohr

- Believed in quantum mechanics
  - Thought entanglement existed
- Ultimately, Bohr turned out to be correct

Impact & Applications

- Immense speedup
  - Solving complex equations
    - Med - Molecular related simulations + calculation
- Cryptography
  - More secure, hackers need to know quantum mechanics to crack codes
  - Quantum encryption → encrypt data
- Teleportation & long distance comm
  - Built off of entanglement theory
- *Machine Learning = pattern recognition*
  - *Dealing with large datasets*
  - *More permutations of large data = more comparisons = more powerful AI*

Examples of How Quantum Computers Work

Classical Computer

1. Players can only use feet to kick ball
2. No hands allowed

Quantum Computer

1. Players use both feet and hands
   a. Rules of game changed : classical physics → quantum physics
2. In some cases faster for athlete to use hands; other cases → feet is better option
   a. Similarly, quantum computers can't speedup all problems

Examples of How Quantum Computers Work

Classical Computer

1. Peel each onion layer
2. Then chop up each individual layer
3. End up with result
4. More time consuming

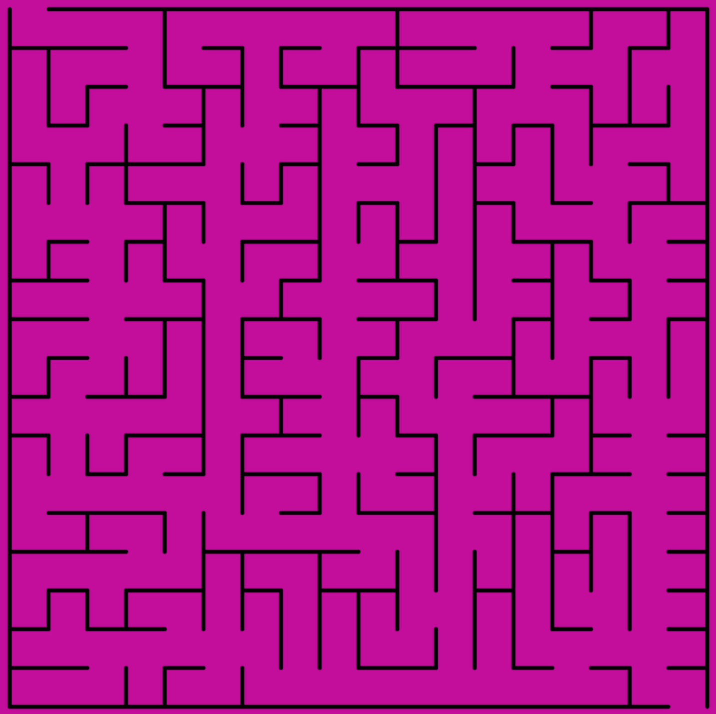
Quantum Computer

1. Chop through all layers at one go, iterating process till onion is completely chopped
2. Analogous to superposition
3. More time efficient

Examples of How Quantum Computers Work

Classical Computer

1. Starts exploring each path
2. Eventually gets out of one of the exits
3. Not as efficient, large time complexity

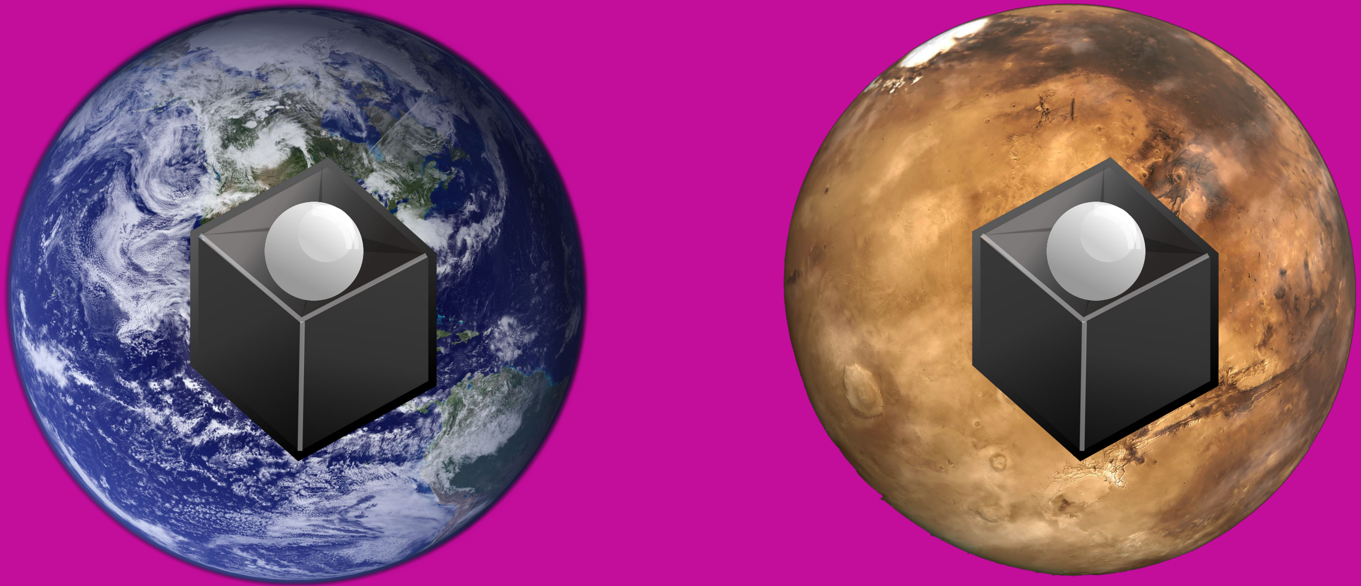


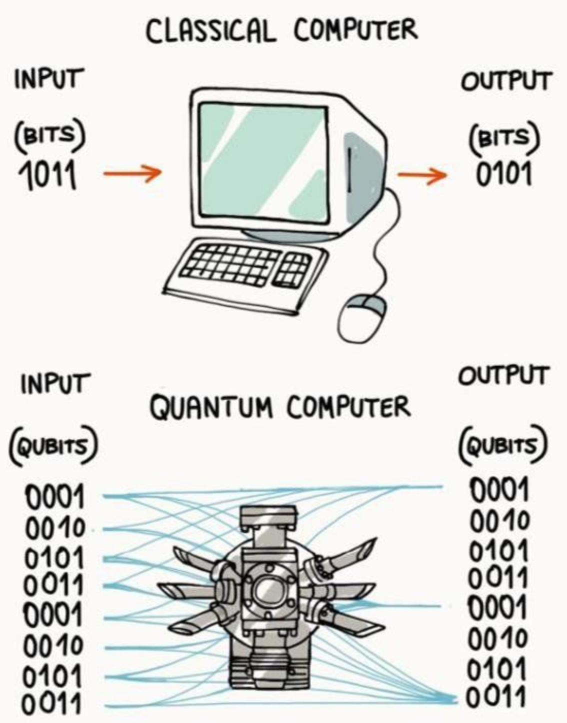
Quantum Computer

1. Have several clones of yourself
2. Everyone starts exploring path, one finds exit
3. Superposition of states like qubit
4. More time efficient

Examples of How Quantum Computers Work

Examples of How Quantum Computers Work



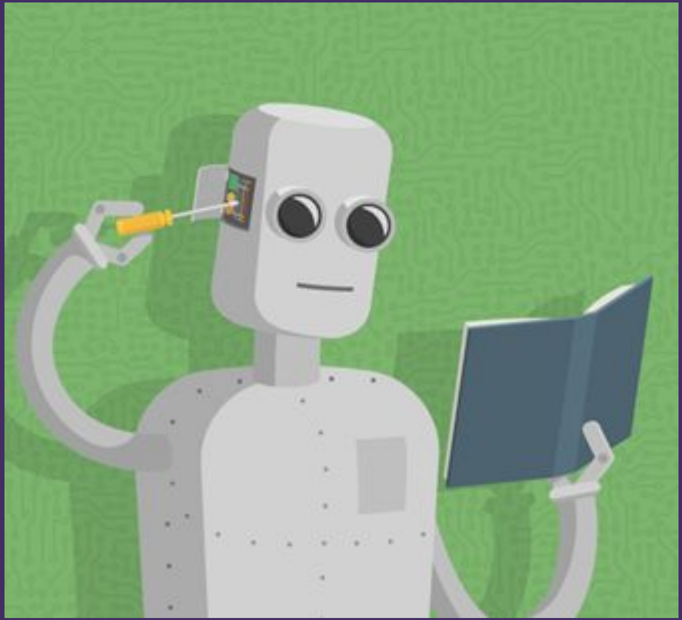


- A QUANTUM SYSTEM REPLACES CLASSICAL BITS WITH QUANTUM QUBITS
- QUBITS FOLLOW THE SUPERPOSITION PRINCIPLE AND CAN EXIST AS "0" AND "1" AT THE SAME TIME
- USING QUBITS INSTEAD OF BITS, WITH A SINGLE IMPUT ONE COULD PROCESS ALL THE POSSIBLE COMBINATIONS OF "0" AND "1"'S IN A STRING AT THE SAME TIME
- QUANTUM ALGORITMS USING THIS ABILITY COULD SOLVE CERTAIN TYPES OF PROBLEMS MUCH, MUCH FASTER THAN ANY CLASSICAL COMPUTER

Machine Learning – A Branch of AI

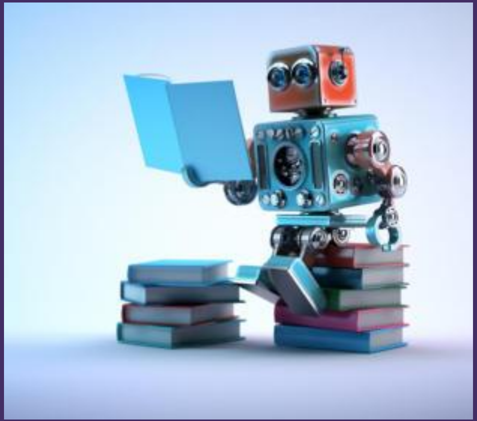
What is Machine Learning?

- ★ Type of AI
  - ○ Subfield
- ★ Use statistical techniques
  - ○ Computers learn with data
  - ○ Not hard core programming



Importance

- ★ Make machine smart by learning from data
- ★ Objective : make most accurate model
  - Churn datasets for prediction
- ★ Prediction → Number of factors & intensity + randomness of outcome



Applications

- Snapchat filters & Facebook friend tagging
  - Image recognitions
- Health monitoring
  - Personal data is fed → machines better understand data
- Price changes when buying things online
  - Track patterns of prices in certain products and predict new price

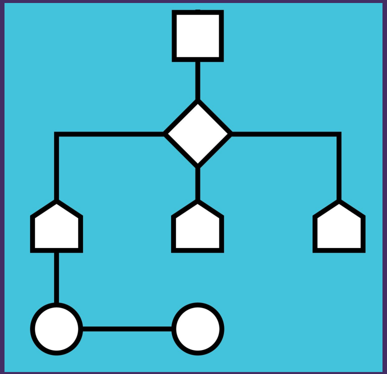
Applications

- ★ Siri + Cortana
  - ○ Neural nets to understand human interaction
- ★ Google Maps
  - ○ Faster routes → less travel time
- ★ Google search recommendations
- ★ Netflix movie recommendations
- ★ Spotify’s music recommendations

Quantum AI + Quantum Machine Learning

Connection to Quantum Computing + Mechanics

- Using quantum mechanics → new quantum computers
- Quantum algos run on quantum computers
- Can make AI even more powerful
  - Quantum AI/ML
    - Algos vary from classical algos



Understanding Quantum AI

- Advanced math (Linear Algebra) needed & strong understanding of advanced computing algos
- Instead → focus mainly on concepts + Python programming

Ted Talk Explaining Quantum Computing

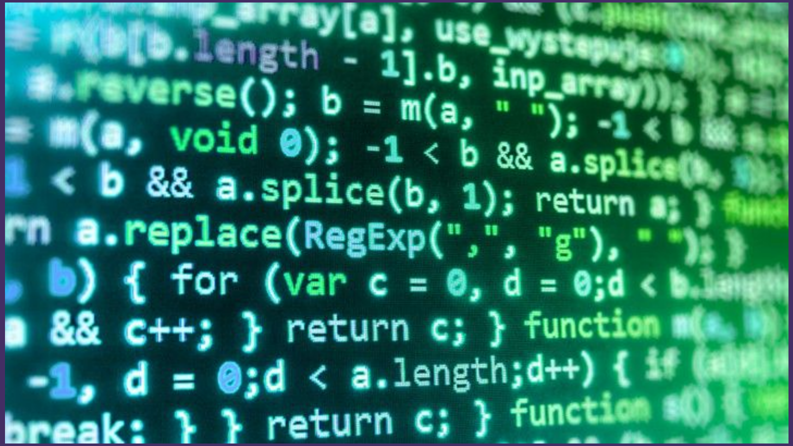
https://www.youtube.com/watch?v=QuR969uMICM

Join Github Page

https://github.com/AI-Inspire

Next Session

python



Hope you've learned something new about Quantum!