Quantum-Inspired Algorithms: Harnessing Quantum Benefits in the NISQ Era

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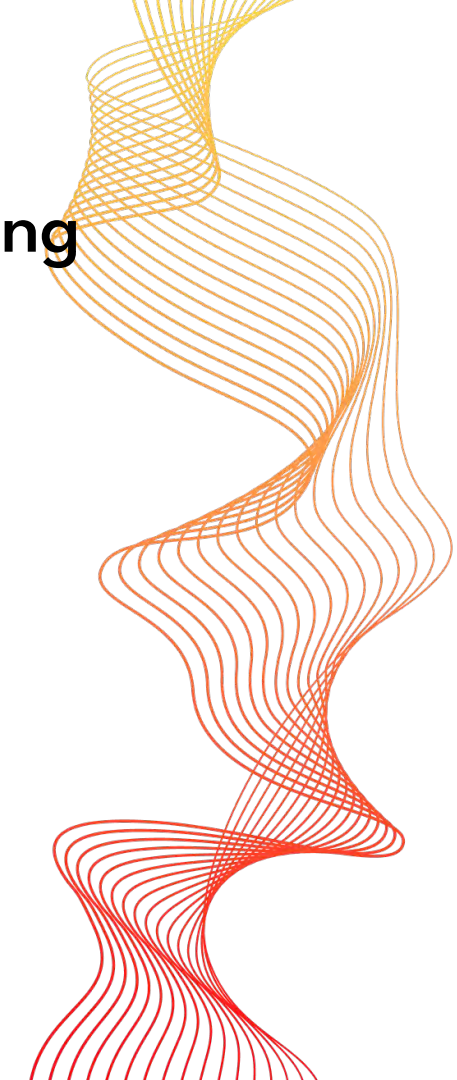
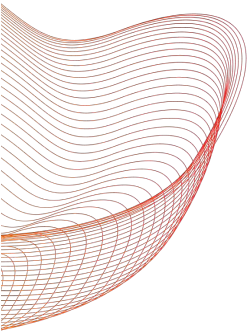


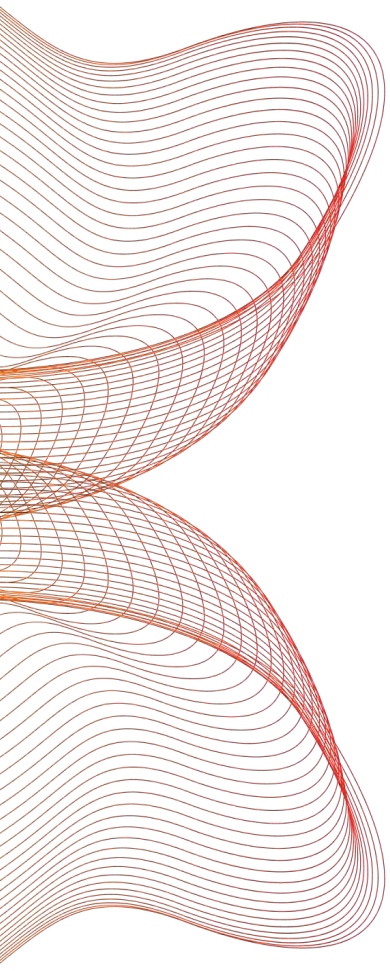
Introduction

Emphasize the potential of quantum computing to solve complex issues.

Emphasize the limitations of the current NISQ (Noisy Intermediate-Scale Quantum) era of quantum computing.

Introduce the concept of quantum-inspired algorithms as a means to obtain quantum benefits within the NISQ era.



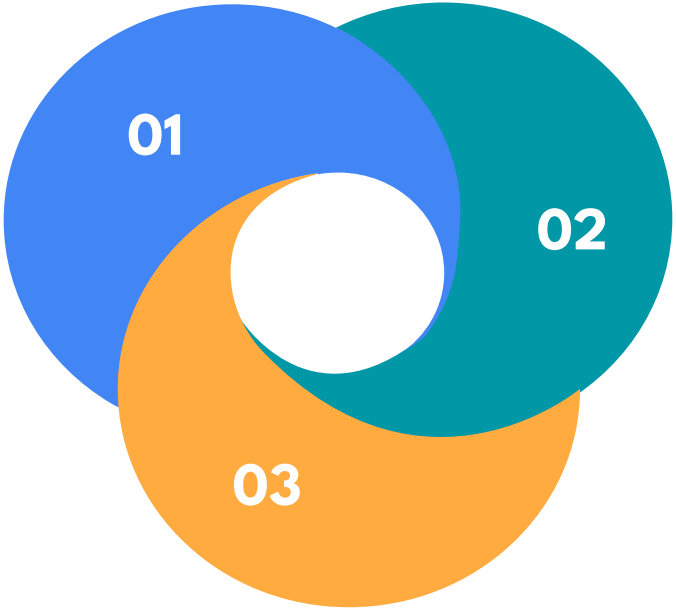


Understanding the NISQ Era

- Key characteristics and challenges of the NISQ era.
- Limitations of current quantum hardware, such as noisy qubits, short coherence times, and limited gate operations.
- Need for alternative approaches to leverage the power of quantum computing.

What are Quantum-Inspired Algorithms?

Define quantum-inspired algorithms as classical algorithms inspired by quantum principles.



Discuss the motivation behind developing such algorithms, i.e., to exploit quantum concepts and gain quantum-like advantages using classical hardware.

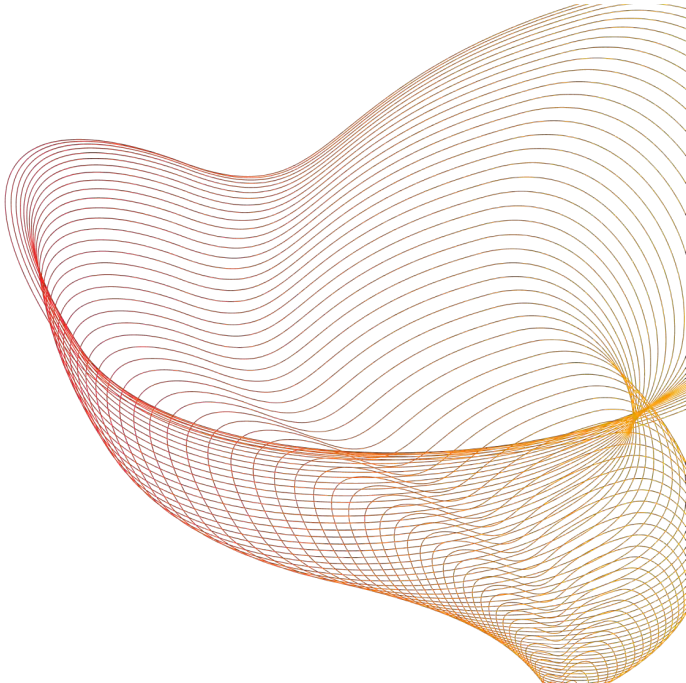
Explain the concept of quantum parallelism, quantum annealing, and quantum tunneling, which are often emulated in quantum-inspired algorithms.

Key Quantum-Inspired Algorithms

01 Provide examples of real-world applications where these algorithms have shown promising results.

02 Discuss prominent quantum-inspired algorithms used in the NISQ era, such as Quantum Approximate Optimization Algorithm (QAOA), Variational Quantum Eigensolver (VQE), and Quantum Neural Networks (QNNs).

03 Explain the working principles and key components of each algorithm.

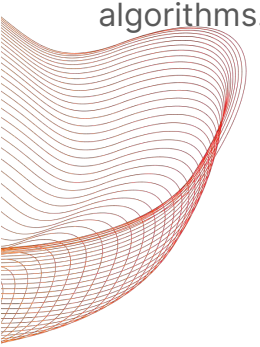


Benefits and Challenges of Quantum-Inspired Algorithms

Highlight the advantages of quantum-inspired algorithms, including improved performance in solving optimization, machine learning, and simulation problems compared to classical algorithms.

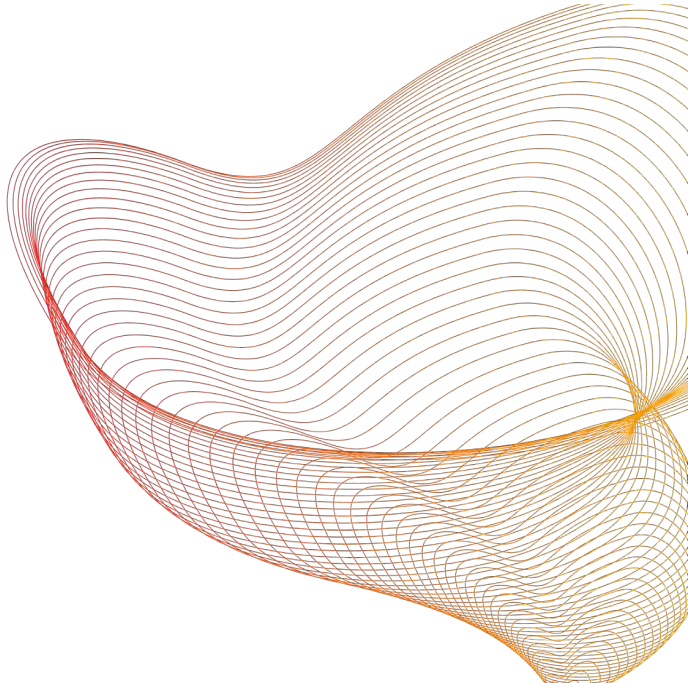
Discuss the potential for quantum-inspired algorithms to serve as a bridge between classical and quantum computing.

Address the challenges associated with quantum-inspired algorithms, such as scalability, computational complexity, and limitations in achieving full quantum speedup.



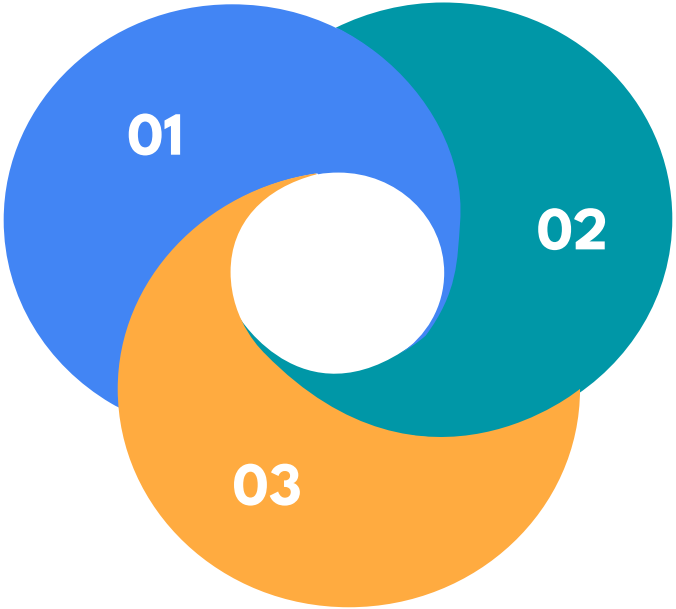
Future Perspectives and Applications

- Discuss ongoing research and development in quantum-inspired algorithms.
- Explore potential applications in various fields, such as finance, logistics, drug discovery, and cryptography.
- Highlight the role of quantum-inspired algorithms in preparing for the eventual arrival of fault-tolerant, universal quantum computers.



Conclusion

Recap the potential of quantum-inspired algorithms in obtaining quantum benefits within the NISQ era.



Highlight the importance of quantum-inspired algorithms in expanding the capabilities of classical hardware.

Summarize the key takeaways from the presentation.

Thank you for your time and attention 🙂

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Quantum Inspired Algorithm

Quantum Comp → Complex Problem

↳ Qubits → ... → n+1

↓

2^n $\$(x)$

* T.S.P
* To , & C.O.P

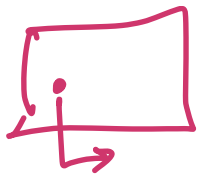
* Limitations of Current Hardware ?

* Scalability : ?

N → 120 → Hard

n m

* Annealing
* Gate Based
* Topological Qubits



N Qubits
↳ n ↑

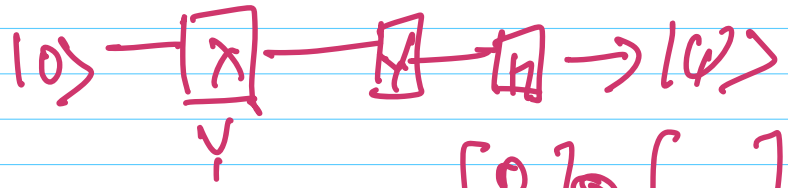
* Noisy Qubits :

$|\psi\rangle \rightarrow$ Inf.

↓ Decoh.

$|0\rangle$

* Decoherence
* Error Propagation



$|1\rangle \begin{bmatrix} 0 \\ 1 \end{bmatrix} \otimes [\ ] \rightarrow$ //

$|\psi_1\rangle \xrightarrow[\epsilon_1]{} |\psi_2\rangle \xrightarrow[\epsilon_2 = \epsilon_1 + \epsilon_2]{} |\psi_3\rangle$

$\Rightarrow$ Limit to # of Gates (C.D)

Algorithm

# of Qubits ↑

N → n → ↓

↳ m ↑

* QEC

↳ Error Corn Codes

↳ ***

* Calibration Issues

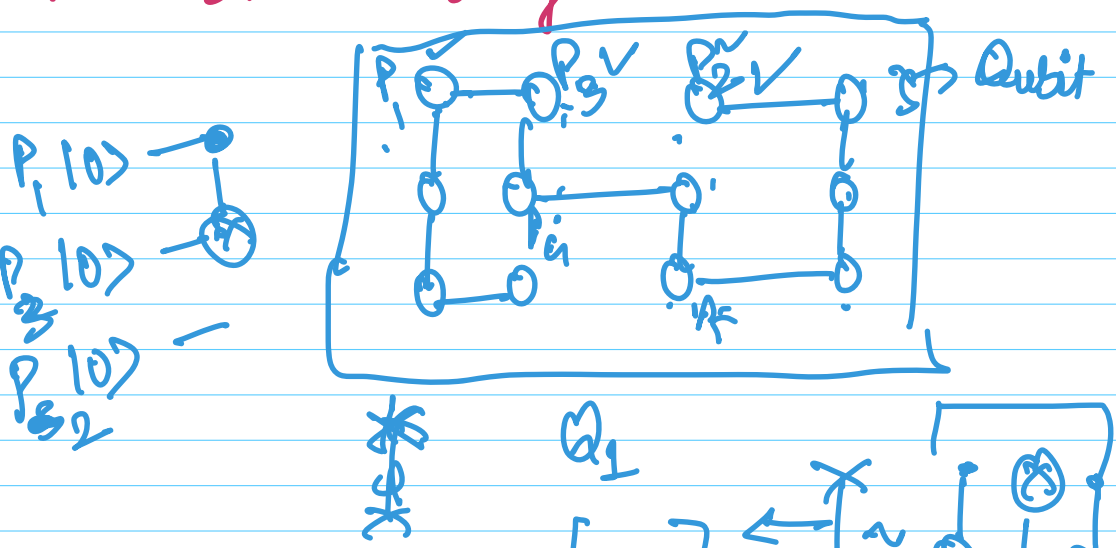
↳ Variable

$|0\rangle, |1\rangle$

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

$P_1 \simeq P_2$

* Qubit Connectivity



$P_1|0\rangle$

$P_3|0\rangle$

$P_2|0\rangle$

Q_1

3 CNOT

↳ 2 Sngl → 6 [ ]

8×6 = 48

[ ]

N I S Q → Quant

N → Noisy

I → Intern

S → Scalable

Quantum → Q. M

Inspired → Simulating

Algorithm → Series

Perfa

Benefits

Properties of QM :

* Parallelism (Superposition)

{ H, T } → Qubit

50% → H

50% → T

Qubit → $|\psi\rangle = \alpha|H\rangle + \beta|T\rangle$

$|\alpha|^2$ → .1

$|\beta|^2$ → .9

Case 1

① first → Closed

↳ $|\alpha|^2, |\beta|^2$

↳ 0.5

$\alpha, \beta \rightarrow \frac{1}{\sqrt{2}}$

$\alpha^2 = 1/2 = 0.5 - 50\%$

• $C_1 \rightarrow |\psi_2\rangle \rightarrow H, T$ }

② Opening first → Measurement

$|\psi\rangle \rightarrow \alpha|0\rangle, \beta|1\rangle \rightarrow (|\psi\rangle)$

↳ Superposition

M ✗

1 ↖

$|0\rangle$

↓

~~$\alpha=1, \beta=0$~~

$\alpha=0, \beta=1$

B → H(x)

↳ 0 ⇒ x

↓

$\alpha=1, \beta=0$

H → SB

↓

$\alpha=1, \beta=0$

$2^n \rightarrow$ States

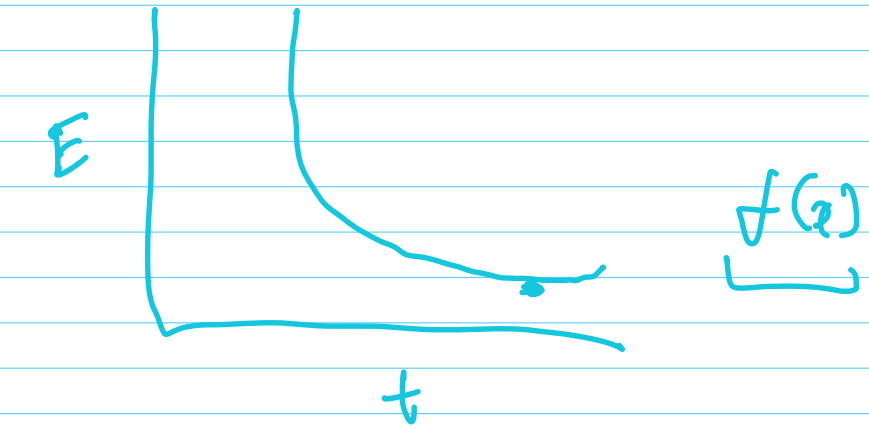
$2 \rightarrow \underbrace{0,1}^{n} \rightarrow BC$ $\{q_1, q_2\}$

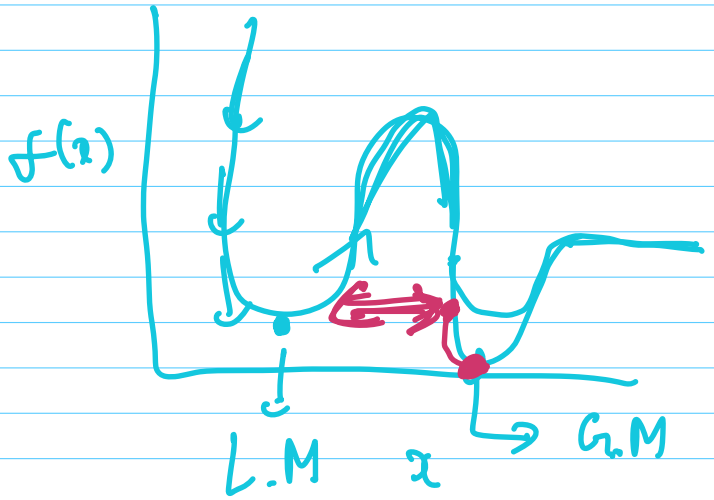
q_1 q_2

$\downarrow$

* Dutch Algorithm.

* Quantum Tunnelling



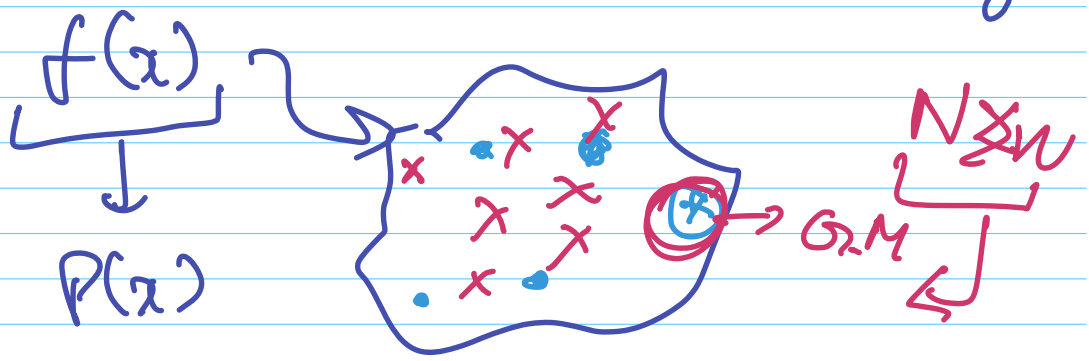


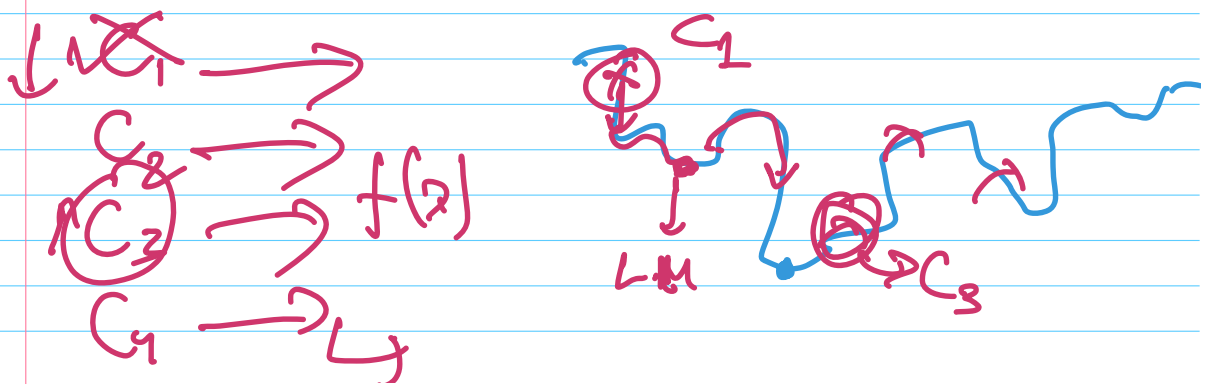
Quantum - Inspired Annealing

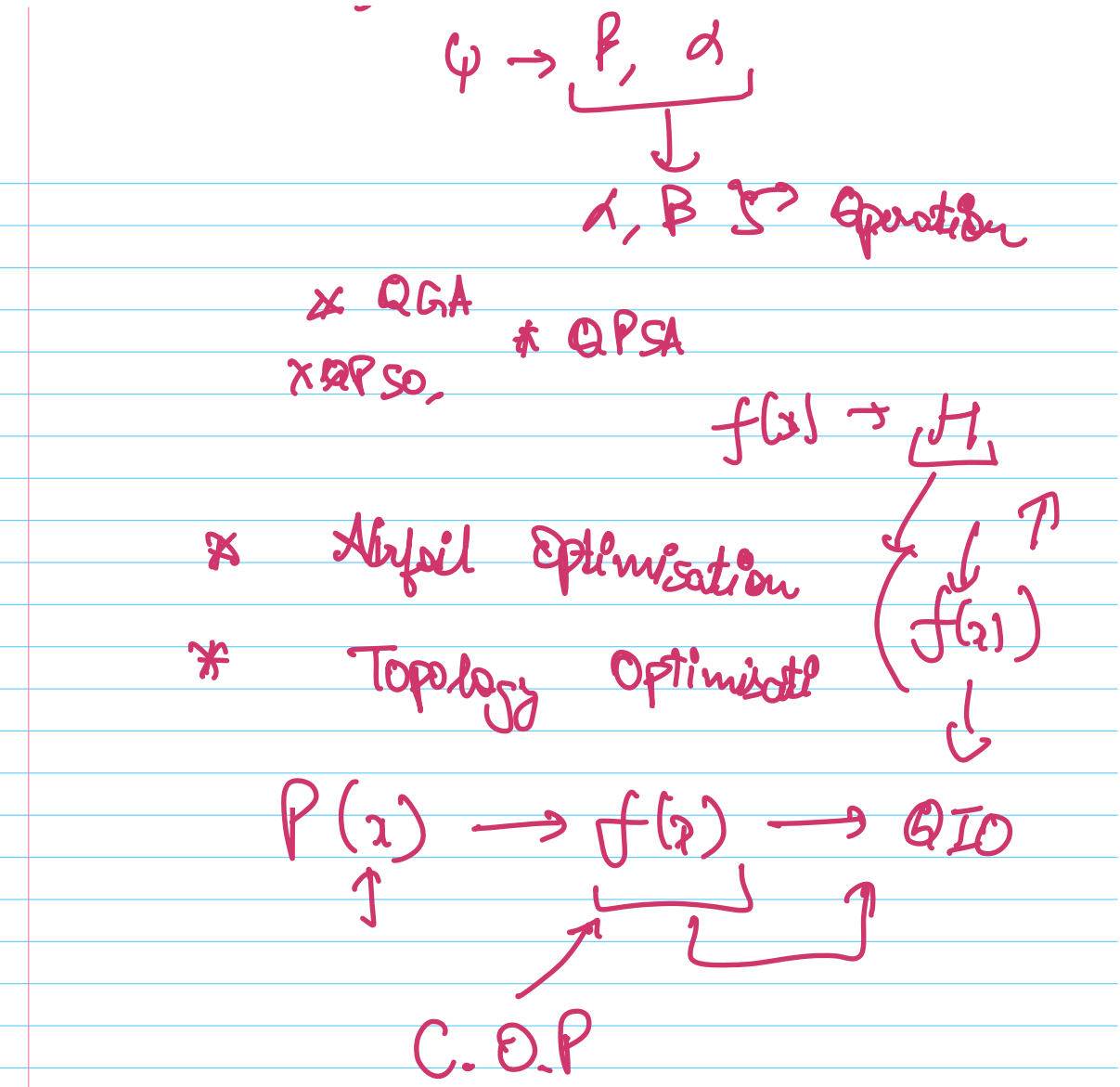
* Quantum Entanglement → QML
→ QIO

Algorithms I

* QIO (Optimisation)
→ Evolutionary → QGA, QPSO, QWO
→ Annealing → Anne Algo






ψ → β, α
↓
λ, β → Equation
* QGA
* QPSA
* QPSO
f(x) → H
* Airfoil Optimisation
* Topology Optimisation
f(x)
P(x) → f(x) → QIO
C.O.P