Quantum artificial intelligence

how quantum computers can help in AI

Content of presentation

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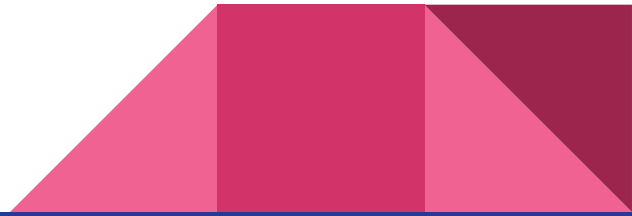


Artificial intelligence

Artificial intelligence is the science of making machines do things that would require intelligence if done by me.

Marvin Minsky, 1967

Quantum computer

Computational device that use in its computation quantum effect like quantum superposition, quantum parallelism and quantum entanglement

Theoretical computational models:

Quantum Turing machine, Quantum circuit, Quantum cellular automata

Why should be interested in?

Company D-Wave already created quantum computer with 2000 qubits working on principle of quantum annealing

http://www.dwavesys.com/press-releases/d-wave-systems-previews-2000-qubit-quantum-system

When Google tested D-Wave's device, they found out, that their quantum computer outperform 100,000,000-times classical simulated annealing or quantum Monte Carlo

https://research.googleblog.com/2015/12/when-can-quantum-annealing-win.html

Company Google might this year (2017) launch full power quantum computer with 50 qubits

http://www.datacenterdynamics.com/content-tracks/servers-storage/google-may-unveil-a-powerful-quantum-computer-by-end-of-2017/96880.fullarticle

Quantum computer

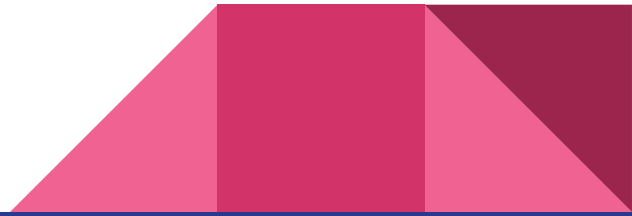
Instead of bits -> qubits (or information unit with more than 2 states)

Quantum superposition -> quantum system can be in its all possible state at the same time (n qubits -> 2^n states)

Quantum parallelism -> manipulation with all states at the same time

possibility of exponential speed-up

Quantum entaglement

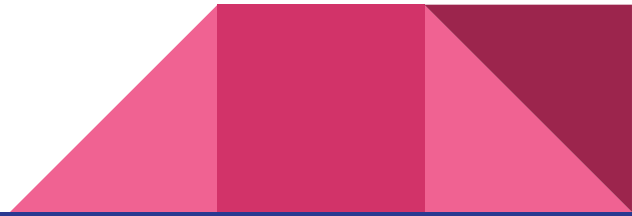


Quantum system with n qubits can contain more than n classical bits, but we can obtain from it only at most n classical bits (Holevo’s theorem)

https://en.wikipedia.org/wiki/Holevo%27s_theorem

Set of classical algorithms for which a quantum speed-up exists has probability measure 0. (Ozhigov 1998)

https://arxiv.org/abs/quant-ph/9803064



Quantum annealing

https://arxiv.org/ftp/arxiv/papers/1404/1404.2465.pdf

Quantum FFT

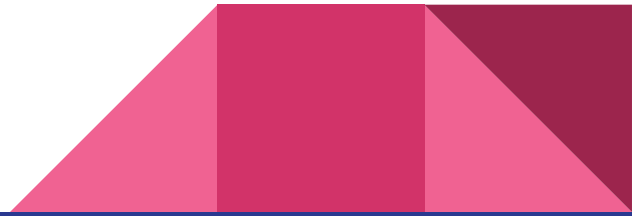
For example it’s used for finding of period of function

Exponentially faster than classical FFT (O(n^2) quantum gates, n is number of qubits)

QFFT is used in Shor’s algorithm and for this reason is integer factorization effective on quantum computers

https://en.wikipedia.org/wiki/Quantum_Fourier_transform

https://arxiv.org/abs/quant-ph/9508027



Grover’s algorithm

Originally for this problem - unordered set where we look for one element with unique property

many generalization

Compared to classical case - quadratic speed up

Application for example in solving NP-complete problems

https://arxiv.org/pdf/quant-ph/0301079v1.pdf

Quantum computers in AI

Quantum tree search

For case binary tree

quantum state of n qubit register -> path from root to leaf

assuming depth of tree = n

Then use Grover’s algorithm -> quadratic speed-up compared to classical ree search

Also we can made analogically iterative deepening

https://arxiv.org/pdf/1502.01951v1.pdf

Quantum neural networks

Quantum information proccesing

Finding quantum effects that have effect? in brain

https://en.wikipedia.org/wiki/Quantum_neural_network

Tested for example on classification of handwritten digits

https://medium.com/the-physics-arxiv-blog/first-demonstration-of-artificial-intelligence-on-a-quantum-computer-17a6b9d1c5fb#.ahsuqbmtv

Quantum machine learning

Excluding neural network there are also variants of others classical algorithms

quantum SVM, quantum clustering, quantum PCA, …

Typically using quantum annealing or Grover's algorithm

https://en.wikipedia.org/wiki/Quantum_machine_learning

https://en.wikipedia.org/wiki/Quantum_algorithm_for_linear_systems_of_equations (another quantum algorithm that exponentially speed-up; algorithm is from year 2009)

Thanks for attention

Question?