Video Processing on Quantum Computers

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This is a Forward-Looking Presentation





Agenda





What is "Quantum"?

- At small scales, physical properties quantized into discrete "basis states"
- Wave function (ψ) describes a superposition of possible basis states
- Measurement causes wave function collapse to a single basis state
- States can be entangled together, such that the measurement of one basis state influences the measurement of another basis state
- **Probability** of measuring a basis state is $|\psi|^2$





Why? Quantum Computing Speedups



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Quantum Algorithms Faster than Classical:

- Factor large integers (Shor's algorithm)
- Unstructured search (Grover's algorithm)
- Simulating quantum systems, e.g. molecules
- Quantum machine learning algorithms
- Quantum optimization algorithms



QuEra Aquila 256-qubit neutral ion QPU

Quantum Superposition

"Ket" notation



Quantum Entanglement Circuit (Bell State)

Gate Name	Symbol	Simplified Effect*	Phenomenon
Hadamard	-H	$ 0\rangle \rightarrow \frac{ 0\rangle + 1\rangle}{\sqrt{2}}$	Superposition
Controlled NOT (aka CNOT)	Control	if $Control = 1\rangle$: $ 0\rangle \rightarrow 1\rangle$ $ 1\rangle \rightarrow 0\rangle$	Entanglement



- You might measure $|00\rangle$
- You might measure $|11\rangle$

But you won't measure $|01\rangle$ or $|10\rangle$

* Quantum gates are actually just linear matrixes

Amazon Braket Program

```
# configuration
```

•••

```
# create the Bell State circuit
bell = Circuit().h(0).cnot(0, 1)
```

```
# choose quantum computer
device = AwsDevice(
"arn:aws:braket:us-east-1::device/qpu/ionq/Aria-1")
```

```
task = device.run(bell, s3_folder, shots=1000)
print(task.result().measurement_counts)
```

Run on IonQ Aria 1 Quantum Computer



(Aria 1 has 25 algorithmic qubits of EM trapped ytterbium ions)



Novel Enhanced Quantum Representation (NEQR)



• Qubits for:

- Y,X coordinates &
- color information
- Create superposition of all Y,X coordinates
- Entangle color information of each pixel with its Y,X coordinates

$$I = \frac{1}{2} \begin{pmatrix} |0000\rangle + |0101\rangle + \\ |1010\rangle + |1111\rangle \end{pmatrix}$$



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 $I = \frac{1}{2} \begin{pmatrix} |0000\rangle + |0101\rangle + \\ |1010\rangle + |1111\rangle \end{pmatrix}$



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Other Quantum Image Processing Algorithms

Theoretical support for quantum performance improvement over classical computers with:

- Motion detection
- Edge detection
- Quantum DCT for image compression
- Quantum-accelerated fractal image compression
- Image up- and down-scaling
- Image forensic watermarking



Is the Past Prologue?



1987: Thinking Machines Connection Machine 2 32 GFLOPS







Ion-trap QPU

IQM





Today: NISQ

Superconducting QPU

lQuEra>



Analog neutral atom QPU



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37 years later: NVIDIA GeForce RTX 4080 SUPER >100 TFLOPS





Superconducting QPU



Thank you!

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A free introduction to quantum computing and quantum mechanics

