Information is hot

JAKE XUEREB

Whilst I am sure some of you find some sexual appeal in strings of 0s and 1s, that's not what I'm getting at. The claim I am making is that the processing of information is a fundamentally thermodynamic endeavour. Just by jumbling up 0s and 1s I can heat a system up or cool it down. Let's see how.

We have to start by acquainting ourselves with entropy. Entropy is a two-faced creature. One of the faces is due to Claude Shannon, who expressed the idea of entropy as a measure of the uncertainty in some information. You receive a handwritten note but one of the words is smudged. That smudge has increased the entropy of that note because the number of possible meanings has now increased.

The other face belongs to Ludwig Boltzmann. He taught us that if we are trying to understand the heat of a gas, it is important that we understand what is going on with each particle in that gas. The temperature of the gas is then an average of the individual behaviour of each constituent particle. As a result of this averaging, it turns out that a system at a specific temperature can correspond to a number of different configurations of these particles. The greater the number of different configurations, the greater the ambiguity and so the greater the entropy. These two pictures are equivalent. Two heads of the same cerberus.

The first person to acknowledge these two heads of entropy was James Clerk Maxwell. He imagines a demon, with perfect knowledge of the velocity of each particle of a gas in a box. This box has a partition in the middle and Maxwell's demon can open and close this partition. Using his knowledge and the partition he separates fast particles from slow ones. Heating one side of the box and cooling the other by doing nothing more than changing information.

The image above is an artistic rendition of the ideas behind today's two main articles. The two-headed cerberus, entropy, formed by Claude Shannon and Ludwig Boltzmann. And, to the right, two quantum computers carrying out a quantum teleportation algorithm. PHOTO: JAKE XUEREB

Changing the information content of a system has thermodynamic repercussions.

I have studied this idea in the quantum realm. Here, the ways we can manipulate information are even more multifaceted. We are empowered by quantum properties like entanglement and coherence to affect the thermodynamics of a system in ways which would shock Maxwell's demon.

Jake Xuereb is a research student working on the thermodynamics of quantum information processes with Quantumalta at the University of Malta. Sometimes, he makes startups too.

MYTH DEBUNKED

Building a teleporter

The teleporter is a sci-fi staple, featured in everything from *Star Trek* to *The Fly*. Who hasn't dreamed of cutting down their commute using a teleporter! Heck, it might even cost less than the Marsa junction project. But would it? How feasible is building a teleporter and how would it work?

Let's start small and extrapolate from there, teleporting a sugar cube.

Our sugar cube is made of sucrose molecules. A combination of carbon, hydrogen and oxygen atoms. Molecules are quantum objects so their information can be encoded and simulated very faithfully on a quantum computer. The teleporter must then transfer this information, called a quantum state, from location A to location B. With quantum computers, special quantum bits of information known as entangled qubits allow us to transfer this information from A to B without a connection between the two locations. Operating on the entangled qubits at B we can recreate the information of A.

We have a plan! Encode your sucrose molecule onto a quantum computer, teleport this information to a quantum computer at your desired destination and reconstitute the sugar from the simulation.

But aye, there's the rub. Sucrose has 12 carbons, having four outer electrons, 22 Hydrogens, having one electron, and 11 oxygens having five outer electrons. All told, that's 48+22+55 = 125 electron orbitals to model, meaning 250 qubits to account for spin. IBM is hoping to announce a 127-qubit machine later this year and we're still a long way from 250 qubits.

Scale this to a human with $7X10^{27}$ atoms and you'd need a gargantuan number of qubits to carry out our plan; requiring two quantum computers, likely each the size of a planet (using today's technology) and spending enough money to build a countable infinity of Marsa junctions.

PHOTO OF THE WEEK

This giant moray eel literally bit off more than it could chew when it attacked this porcupine pufferfish. These tiny fish are famous for their ability to 'blow' themselves up when attacked, by ingesting large amounts of water (or air) they can expand their hyper elastic stomach, transforming into a virtually inedible ball several times their normal non-inflated proportions. PHOTO: KIRBY MOREJOHN

DID YOU KNOW?

- The winner of the first modern Olympic Marathon stopped at a tavern mid-race for a glass of wine.
- For Christmas 1936, Salvador Dalí sent Harpo Marx a harp with barbed-wire strings. Harpo sent back a photograph of himself with bandaged fingers.
- The board game 'The Campaign for North Africa' is famously complex. It has 1,800 pieces, three volumes of rules, and takes teams of five 1,500 hours to complete.
- 'Scruple' originally comes from the Latin *scrupulus*, a small sharp stone that has got caught in your sandal.
- Speaking about the parrot's ability to mimic human speech, Aristotle wrote that the bird "becomes even more outrageous after drinking wine".

For more trivia see: www.um.edu.mt/think

SOUND BITES

- Investigating how climate affects intense rainstorms across Europe, climate experts have shown there will be a significant future increase in the occurrence of slow-moving intense rainstorms. The scientists estimate that these slow-moving storms may be 14 times more frequent across land by the end of the century. It is these slow-moving storms that have the potential for very high precipitation accumulations, with devastating impacts, as we saw in Germany and Belgium.

HTTPS://WWW.SCIENCEDAILY.COM/RELEASES/2021/07/210716150752.HTM

- Researchers have recently identified a DNA region known as VNTR2-1 that appears to drive the activity of the telomerase gene, which has been shown to prevent ageing in certain types of cells. Knowing how the telomerase gene is regulated and activated and why it is only active in certain cell types could someday be the key to understanding how humans age and how to stop the spread of cancer.

HTTPS://WWW.SCIENCEDAILY.COM/RELEASES/2021/07/210723105258.HTM

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