

I, Internet: will www switch on to itself?

Terrence Sejnowski

The human brain is the most complex computing device in the known universe. The product of hundreds of millions of years of evolution, it wires itself up during development as it interacts with the world beyond. And, eventually, it becomes aware of itself. The internet, by contrast, is only 37 years old. Yet it has been growing exponentially since then and already circles the globe. Although I can depend on my brain to recall an enormous amount of information, with the aid of the internet I have achieved omniscience for all practical purposes. The net's power rests on its ability to access almost instantly information anywhere on the planet. Just last week, I used it to track down potential reviewers for papers submitted to the journal *Neural Computation*, to plan a trek in Patagonia and to buy a BMW in a distant city. But, at present, the internet answers only the questions we think to ask it. Could it begin to ask its own questions one day?

Sentient computers have long had a place in science fiction, from Hal 9000 in *2001: A Space Odyssey* to V.I.K.I. in *I, Robot*. But such conscious machines do not yet exist in reality despite computer power increasing by more than a billion times since the first electronic models were built in the 1950s. The human brain has a radically different architecture. It uses many billions of relatively slow neurons working together in parallel instead of a single microprocessor working rapidly on a single sequence of instructions. The brain's power derives not just from the large number of neurons, but also from the even larger number of connections between them. In principle, however, a sufficiently fast and large digital computer could simulate the same level of computation that occurs inside our heads. The communication power of the entire internet is now approaching that of the cerebral cortex, the most interconnected part of our brains. The amount of data it contains is comparable to the massive quantity of memory in the cerebral cortex. The internet and our ability to search it are now within reach of the raw storage and communication capacity of the human brain.

The growth of the internet over recent decades more closely resembles biological evolution than engineering. It has attained a size not imagined by its inventors, in contrast to most engineered systems, which often fail when pushed beyond their original design limits. The internet achieves this remarkable scalability because it has the ability to regulate itself, dynamically deciding on the best routes to send the packets of information that make up a message as they flow through a series of hubs on their way to their final destination. Interestingly, although the internet never sleeps, it does have a circadian rhythm that follows the sun as the planet rotates under it - traffic falls as the sun sets and increases as the sun rises, just as we do.

Scientists Christof Koch and Francis Crick have speculated that the key to understanding consciousness is global communication, how neurons in distant parts of the brain manage to coordinate their actions despite their limited connectivity. Almost half of the cortical volume in humans is taken up with long-range connections. Nevertheless, the global connectivity in the

cerebral cortex is extremely sparse. The probability of any two neurons having a direct connection is less than one in a million.

There is growing evidence that information can be efficiently exchanged between widely separated populations of neurons when they become briefly synchronised. The weak electrical activity that can be detected on the surface of the scalp contains hints that the cortex uses synchronised spikes of electricity at different frequencies to make reliable communication possible. This is, perhaps, not unlike the way packets of information fly (much more slowly) around the internet. The cortex also uses a hub system, in which information flows through intermediate areas on its way to its final destination. Perhaps the internet is evolving into something with a structure not unlike the brain.

While there are many physical parallels between the internet and the brain, what has made it "come alive" today is the ability of search engines to retrieve information almost instantaneously. I am often surprised at the hits that Google returns in response to a few keywords - as if it were reading my mind... I suspect it knows who I am. But how would we know if the internet really were to become aware of itself? The problem is that we do not even know if some of our fellow creatures on this planet are conscious in the same way that we are. Could it be that the internet is already aware of itself?

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