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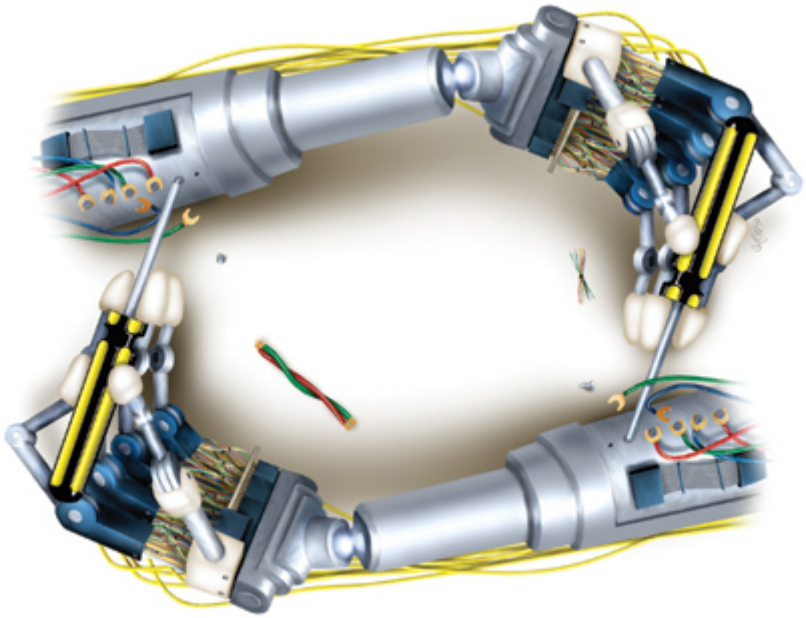
Bad News for Quantum Clones

If bloodthirsty legions of identical self-replicating robots bent on the destruction of humanity haunt your dreams, rest easy. Science has proven that they can't exist--at least not if they have quantum brains. In a paper submitted to *Physical Review Letters*, two physicists have shown that it is impossible to build a quantum "universal constructor"--a quantum computer that has the ability to spawn perfect copies of itself.



Quantum constraint. Robots made of classical components can make identical copies of themselves, but quantum machines can't.

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The idea of a universal constructor goes back more than 60 years to the dawn of the computing age, when John von Neumann, one of the architects of computing theory, started pondering whether self-replicating machines could exist. "It was a step toward trying to understand a living system," says Arun Pati, a physicist at the Institute for Physics in Bhubaneswar, Orissa, India. Von Neumann designed a complex computer program that outputs an exact duplicate of itself--first making a copy of its structure and then breathing life into the copy by giving it a set of instructions that tell it how to replicate.

Now, however, all the old questions of classical computing, such as whether there can be a universal constructor, are being asked again in the quantum

domain. And that question, at least, has been answered with a resounding no. Pati and Samuel Braunstein of the University of Wales, Bangor, have proven that in a universe with finite resources, a quantum robot would be unable to make a perfect copy of itself. So, in a sense, Pati argues, it could never be "alive." That could be bad news for those who speculate that life might have some sort of quantum-mechanical nature, he says.

Not quite, says Seth Lloyd, a physicist at Massachusetts Institute of Technology in Cambridge. Lloyd says that the theorem is almost certainly correct, but he adds that it's not necessary to make an exact duplicate of a machine for it to be able to reproduce like a living creature--an almost-perfect copy will do just fine. "You can reproduce it to an arbitrary degree of precision," he notes. "That's good enough for me." Braunstein agrees and downplays the proof's implications for the nature of life. To Braunstein, the real value of figuring out what quantum computers can and can't do is that it goes to the heart of what makes quantum mechanics so weird. "It gives us a language and a powerful way of thinking of the difference between the classical and the quantum--and about what makes quantum mechanics really tick."

--CHARLES SEIFE

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