The analysis shows that around one-quarter of the total number of retractions are conference papers — and the bulk of those comprise withdrawals by the IEEE, which has pulled more than 10,000 such papers in the past two decades. The IEEE was the publisher with the highest number of retractions. It does not record when it retracts papers, but most of those removed were published between 2010 and 2011.

Preventive measures

Monika Stickel, director of corporate communications at the IEEE, says that the institute thinks its preventive measures and efforts identify almost all submitted papers that do not meet the organization's standards.

However, Cabanac and Kendra Albert, a technology lawyer at Harvard Law School in Cambridge, Massachusetts, have found issues, including tortured phrases, citation fraud and plagiarism, in hundreds of IEEE papers published in the past few years, Retraction Watch reported earlier this year. Stickel says that the IEEE has evaluated those papers and found fewer than 60 that didn't conform to its publication standards, with 39 retracted so far.

The 50,000 or so retractions recorded around the world thus far are only the tip of the iceberg of work that should be retracted, integrity sleuths say. The number of articles produced by 'paper mills' — businesses that

"Paper-mill products are a problem even if no one reads them."

sell bogus work and authorships to scientists — is estimated to be in the hundreds of thousands alone, quite apart from genuine papers that might be scientifically flawed. "Paper-mill products are a problem even if no one reads them, because they get aggregated with others into review articles and laundered into the mainstream literature," says David Bimler, a New Zealand-based research-integrity sleuth also known by the pseudonym Smut Clyde.

'BIOCOMPUTER' COMBINES BRAIN TISSUE WITH SILICON HARDWARE

A system that integrates brain cells into a hybrid machine can recognize voices.

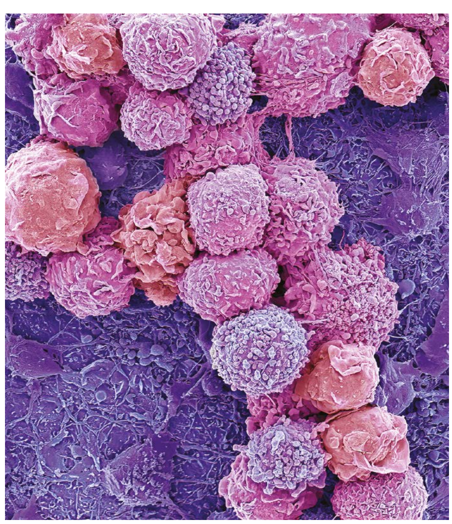
By Lilly Tozer

Researchers have built a hybrid biocomputer — combining laboratory-grown human brain tissue with conventional electronic circuits — that can complete tasks such as voice recognition.

The technology, described on 11 December in *Nature Electronics,* could one day be integrated into artificial intelligence (AI) systems, or form the basis of improved models of the brain in neuroscience research.

The researchers call the system Brainoware (H. Cai *et al. Nature Electron*. https://doi.org/k8vz; 2023). It uses brain organoids — bundles of tissue-mimicking human cells that are used in research to model organs. Organoids are made from stem cells capable of specializing into different types of cell. In this case, they were morphed into neurons, akin to those found in human brains.

The research aims to build "a bridge between AI and organoids", says study co-author Feng Guo, a bioengineer at the University of Indiana Bloomington. Some AI systems rely on a web of interconnected nodes, known as a neural network, in a similar way to how the brain functions. "We wanted to ask the question of whether we can leverage the biological neural network within the brain organoid for computing," Guo says.



STEVE GSCHMEISSNER/SPL

Part of a brain organoid.

Harnessing brainpower

To make Brainoware, researchers placed a single organoid onto a plate containing thousands of electrodes, to connect the brain tissue to electric circuits. They then converted the input information into a pattern of electric pulses, and delivered it to the organoid. The tissue's response was picked up by a sensor and decoded using a machine-learning algorithm.

To test Brainoware's capabilities, the team used the technique for voice recognition by training the system on 240 recordings of 8 people speaking. The organoid generated a different pattern of neural activity in response to each voice. The AI learnt to interpret these responses to identify the speaker, with an accuracy of 78%.

Although more research is needed, the study confirms some key theoretical ideas that could eventually make a biological computer possible, says Lena Smirnova, a developmental neuroscientist at Johns Hopkins University in Baltimore, Maryland. Previous experiments have shown only 2D cultures of neuron cells to be able to perform similar computational tasks; this is the first time it has been shown in a 3D brain organoid.

Better brain model

Combining organoids and circuits could allow researchers to leverage the speed and energy efficiency of human brains for energy-intensive AI, says Guo.

The technology could also be used to study the brain, says Arti Ahluwalia, a biomedical engineer at the University of Pisa in Italy, because brain organoids can replicate the architecture and function of a working brain in ways that simple cell cultures cannot. There is potential to use Brainoware to model and study neurological disorders, such as Alzheimer's disease. It could also be used to test the effects and toxicities of different treatments. "That's where the promise is; using these to one day hopefully replace animal models of the brain," says Ahluwalia.

But using living cells for computing is not without its problems. One big issue is how to keep the organoids alive. The cells must be grown and maintained in incubators, something that will be harder the bigger the organoids get. And more complex tasks will demand larger 'brains', says Smirnova.

To build on Brainoware's capabilities, Guo says that the next steps include investigating whether and how brain organoids can be adapted to complete more complex tasks, and engineering them to be more stable and reliable than they are now. This will be crucial if they are to be incorporated into the silicon microchips that are currently used in AI computing, he says.