"Hydrogel Brain" Uses Deep Learning to Surpass Expectations

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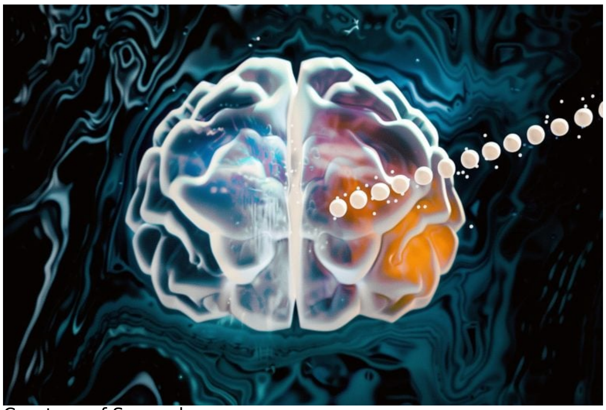

Courtesy of Synevol

A group led by Dr. Yoshikatsu Hayashi showed in a paper published in Cell Reports Physical Science that a basic hydrogel, a kind of soft, flexible material, can be taught to play the straightforward computer game "Pong" from the 1970s. Over time, the hydrogel's performance improved when it was interfaced with a computer simulation of the classic game using a specially designed multi-electrode array.

As stated by Dr. Hayashi, a biomedical engineer from the School of Biological Sciences at the University of Reading: "Our research demonstrates that even very simple materials can exhibit complex, adaptive behaviors typically associated with sophisticated AI or living systems."

"This presents intriguing opportunities for creating novel'smart' materials that are able to perceive and adjust to their surroundings."

It is believed that charged particles in the hydrogel migrate in response to electrical stimulation, forming a kind of "memory" within the material itself, which is the source of emergent learning behavior.

Robotics engineer Vincent Strong, the initial author, states that "ionic hydrogels can achieve the same kind of memory mechanics as more complex neural networks." Strong is affiliated with the University of Reading. "We demonstrated that hydrogels can learn to play Pong and become increasingly proficient at it over time."

The earlier study, which shown that brain cells in a dish can pick up the game of Pong if they are electrically stimulated in a way that provides them with performance feedback, served as motivation for the researchers.

Dr. Hayashi, a corresponding author on the study, stated, "Our paper addresses the question of whether simple artificial systems can compute closed loops similar to the feedback loops that allow our brains to control our bodies."

The fundamental idea behind ions' movement and distribution in hydrogels and neurons alike is that they can serve as memory functions that are correlated with sensory-motor loops in the context of Pong. Ions circulate throughout the cells of neurons. Outside, they run in the gel.

According to the researchers, hydrogels offer a different sort of “intelligence” that might be utilized to create new, simpler algorithms, as neural networks are the basis for the majority of AI algorithms currently in use. Future investigations into the hydrogel's "memory" will involve assessing the material's capacity for additional activities as well as studying the mechanics underlying memory.

Dr. Hayashi's team, along with Reading colleagues Dr. Zuowei Wang and Dr. Nandini Vasudevan, showed in a recent related study that was published in the Proceedings of the National Academy of Sciences how an external pacemaker may be trained to beat in time with a different hydrogel substance. This is the first time a material other than living cells has been used to do this.
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The scientists showed how a hydrogel substance oscillates mechanically and chemically in a manner similar to the coordinated contraction of heart muscle cells. These dynamic phenomena are explained theoretically by them.

The scientists discovered that they could synchronize the chemical oscillations of the gel with the mechanical rhythm by subjecting it to repeated compressions. This entrained heartbeat was remembered by the gel even after the mechanical pacemaker was turned off.

"This is an important step toward creating a cardiac muscle model that may be utilized in the future to investigate the interaction between chemical and mechanical signals in the human heart," stated Dr. Hayashi. "It opens up exciting possibilities for these chemically-powered gel models to replace some animal experiments in cardiac research."

Dr. Tunde Geher-Herczegh, the study's lead author, stated that the results may open up new avenues for research on cardiac arrhythmia, a disorder that affects over 2 million people in the UK and causes the heart to beat too quickly, too slowly, or irregularly.

"Drugs or an electrical pacemaker can be used to treat an irregular heartbeat, but studying the mechanical systems that underlie an irregular heartbeat independently of the chemical and electrical systems in the heart is challenging due to the complexity of biological heart cells," the speaker stated.

"Our findings will further our understanding of how artificial materials could be used in place of animals and biological tissues for research and treatments in the future, and could lead to new discoveries and potential treatments for arrhythmia."

These investigations, which connect ideas from the fields of materials science, neurology, physics, and cardiac research, imply that the basic ideas behind learning and adaptation in living systems may be more widespread than previously believed.

The research team thinks that a wide range of industries, including environmental sensing, prosthetics, soft robotics, and adaptive materials, may be impacted by their findings. Subsequent research endeavors will center on the advancement of intricate behaviors and the investigation of plausible practical uses, such as the creation of substitute laboratory models to promote cardiac research and mitigate the utilization of animals in medical investigations.

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