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Robotic probes plumb brain's circuitry

R. Colin Johnson

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PORTLAND, Ore. -- Robots enabled the human genome to be mapped in just over 12 years, but it took less than four years for the Paul Allen--Microsoft co-founder--Brain Atlas to be completed last month by robots. Now researchers at the Massachusetts Institute of Technology (MIT) and Georgia Institute of Technology (Georgia Tech) are hoping to use robots to create a parts list and electrical wiring diagram of the brain, giving companies like IBM a leg-up on creating the cognitive computers of the future.

"By automating the process of measuring electrical activity in the brain with robots, we can now really begin to understand how the brain works," said Georgia Tech engineering professor Craig Forest.

"Imagine being able to stimulate any cell in the brain, and record its response to determine the precise electrical functions of each type of neuron. Now imagine automating the process of measuring the interaction between neurons, say between the hippocampus and the cortex during learning, or between the thalamus and the cortex when you pull your hand from a hot stove."

For the last 30 years, brain science has been hampered by the manual methods required to locate and record the activity of brain cells--called neurons--but this new robot, combined with smart computer algorithms, has now automated the technique, enabling the cataloging of neuron types by their electrical properties. As a result, the researchers hope to build a catalog of necessary brain components and their interconnection method, which will then be used to build future brain-like computers.

The brainchild of Georgia Tech doctoral candidate Suhasa Kodandaramaiah, working in Forest's lab and in cooperation with professor Ed Boyden at MIT, the robot arm guides a micropipette inside a living brain. By measuring the electrical impedance--which is low until a brain cell is encountered--the probe can take two-micron steps until it just touches a neuron--at which time the impedance goes up.

Unlike manual methods which nearly always rupture the cell on contact, the robot can immediately stop before damaging the neuron. Suction is then applied and a tiny electrical probe inserted to record its normal electrical activity while the animal is still alive. After the recording is made, a sample of the cells genetic makeup can be extracted to analyze which genes are currently activated. By repeating the process in all the different regions of the brain, the researchers hope to create a parts list of the brain's neural components, complete with their electrical properties. Next the researchers are planning multi-tip probes so that the robot can measure electrical activity at several points simultaneously, allowing it to create a wiring diagram of how the different regions of the brain interact.

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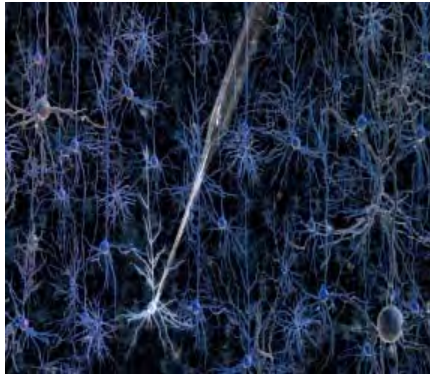
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MIT and Georgia Tech have invented a robotic probe (center) that is creating a parts list and wiring diagram of the brain for chip makers to emulate.
SOURCE: Sputnik Animation and MIT McGovern Institute

"So far we have only worked with lab animals, but eventually we hope to be able to use the technique on humans during brain surgery, to eliminate trial-and-error by determining exactly which neurons are damaged and need to be removed," said Forest.

The researchers hope to determine the electrical signature of many different brain maladies, such as Parkinson's disease, autism and epilepsy, not only to remove diseased neurons, but also in order to facilitate the discovery of drug that return them to normal functioning.

The researchers also expect microchip makers to use their part list and wiring diagram to help create brain-like cognitive computers in projects like the [Systems of Neuromorphic Adaptive Plastic Scalable Electronics \(SyNAPSE\)](#) program at the Defense Advanced Research Project Agency (DARPA).

Labs wishing to adopt the new robotic probe methodology can roll-their-own equipment using detailed instructions provided at [AutoPatcher.org](#), or they can buy complete robotic solutions from the new company started by Kodandaramaiah, Forest and Boyden called [Neuromatic Devices \(Atlanta\)](#).

Funding was provided by the National Institutes of Health, the National Science Foundation and the MIT Media Lab. Other contributors to the work include MIT doctoral candidate Giovanni Talei Franzesi and MIT postdoctoral fellow Brian Chow.

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