BUILDING a virtual brain

THE GLOBE AND MAIL AUGUST 15, 2009

Neuroscientist Randy McIntosh with his virtual brain, composed of powerful computers and racks of servers.

In a chilly room that once housed patients at Baycrest's Rotman Research Institute in Toronto, Randy McIntosh and his colleagues are trying to build a brain.

Their virtual brain – still under construction – is composed of powerful computers, linked in a grid, and racks of servers, cooled by fans.

It is still early days in the ambitious multimillion-dollar project that could take 10 years to complete. "You could almost call it a fetal brain in some respects," says Dr. McIntosh, a neuroscientist at the institute.

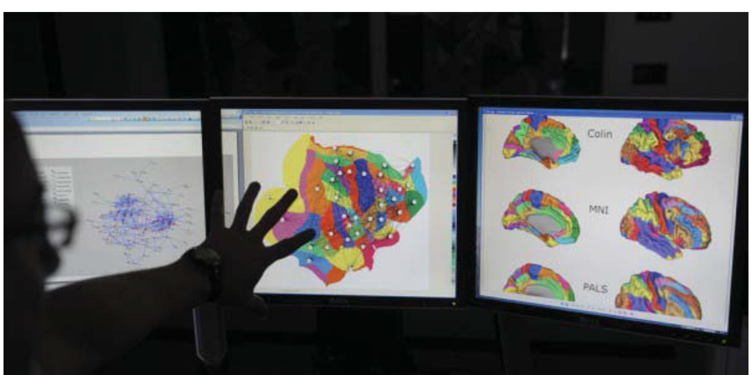
The idea is to create a machine that will mimic basic patterns of brain activity that occur when people are doing a variety of things, such as recognizing faces or reading.

So far, Dr. McIntosh and his colleagues have been able to recreate what the brain does when it is resting. This may sound easy, but it involves replicating a stereotypical pattern of activity across the brain that has been documented by other researchers using scans and equipment that measures electrical activity.

From this work, Dr. McIntosh knows the details of what a brain at rest is doing – and generates the same activity in the artificial brain, programming the virtual structures to do the same thing as their real-life counterparts.

"You can actually reproduce these patterns," he says.

He and his colleagues were able to map activity in their virtual brain that matched the real thing – maps of the human brain at rest created using a functional magnetic resonance imaging, or an fMRI.



In these brain scans, different colours show the various cognitive functions.

In the future, Dr. McIntosh and his collaborators in the United States, France, Germany, Spain and the Netherlands hope to accurately replicate far more complex functions.

"Can we have it look at a picture? Can we have it listen to a piece of music? Can we have it show emotion? Can we have it get sick?" he says. "When you impose damage or disease, how does the virtual brain recover from a stroke? How does it deal with Alzheimer's disease or Parkinson's disease?"

The goal, Dr. McIntosh says, is to create a machine that helps doctors treat patients. Say someone has a stroke that leaves him unable to speak. A physician could scan the patient's brain, and then input his unique neural architecture into the virtual brain.

Doctors could then identify the networks that need to be targeted for therapy. They might even be able to model the impact of various treatments.

The project is funded with $7.5-million (U.S.) over five years from the American James S. McDonnell Foundation, Dr. McIntosh says, and is now in its third year of that grant. To get the virtual brain into a clinical setting could take an additional $10-million, he estimates.

He and his colleagues are collecting data from different people – infants, adults, elderly, patients – with a number of brain-imaging methods. They also have to develop the necessary structure to archive and access the data and the algorithms to analyze it and synthesize it into the virtual brain.

A team in Switzerland is also working on a virtual brain with the support of IBM. Henry Markram, director of the Blue Brain Project at the Ecole Polytechnique Fédérale de Lausanne, says he has already simulated elements of a rat brain.

That work is focused, at least initially, on the cortical columns, the building blocks of the neocortex, the outermost portion of the brain involved in sensory perception and complex cognitive functions.

Dr. McIntosh and his colleagues are looking more at the brain as a whole. "If you are trying to build a model of a car, you really want to do the whole car, not just the spark plug," he says. "You can model a spark plug and how it fires, but you will miss how the spark plug helps the car move forward."

The next step is to get their virtual fetal brain to mature. Babies have less specialized brains than adults, but as they get older, different parts of their brains take on more specific functions, such as processing information collected by the eyes or the ears.

Dr. McIntosh is hoping to mimic that process, and eventually build a virtual brain that can replicate the neural circuitry of the adult organ. The wildly ambitious project is limited, however, by how little scientists really understand about how the brain works. Brain scans offer at best an overview of brain activity.

"We are getting very little about what is actually going on," Dr. McIntosh says.

Still, neuroscientists probably understand enough about the human brain to build a virtual one that will be helpful in understanding epilepsy, Alzheimer's disease or stroke.

"Certainly, some things that impact stroke recovery are going to be happening at the cellular level that we cannot measure easily in living tissue," Dr. McIntosh says. "But it is a question of do we need that information to make the model useful or not."