Prosthetic limbs that can be controlled by the mind aren’t the stuff of science fiction any more. Such devices, which users operate through a neural implant that translates signals from the brain to the prosthetic, have been shown to work in laboratories around the world, while testing on human patients is just getting underway.

But making these devices work in a lab and making them last over a lifetime for individuals who have lost a limb are very different propositions. Badrinath Roysam, chair of the Department of Electrical and Computer Engineering at the Cullen College of Engineering, is leading a multi-institution team to overcome one of the biggest obstacles to the real world use of these prosthetics: the nearly inevitable failure of the neural implants over time.

In addition to Roysam, the team includes researchers from Rensselaer Polytechnic Institute, Seattle Children’s Research Institute, the University of Michigan, and a firm based in Michigan named MPI Research. The group has received a three-year, $5.4 million grant from the Defense Advanced Research Projects Agency (DARPA) to explore this problem.

According to Roysam, neural implants, which can also be used to stimulate the brain, sample brain fluids or deliver medication, typically fail because the brain treats them like an injury.
The tissue begins remodeling itself right away, Roysam said regarding what happens when a device is implanted in the brain. It’s called a tissue reactive response. Basically reactive cell types envelop the device to the point where it becomes completely isolated from the rest of the brain. At that point, it’s basically ineffective.

While researchers understand the fundamentals of this process, its details are not well known. How, exactly, do different brain cell types react when an implant is introduced? How to the reactive cell types make their way to the neural implant? What happens to the surrounding blood vessels? And how does an implant’s design affect the brain’s response to it?

These are the questions this research group will seek to answer.

The work will begin at the University of Michigan, where professor Daryl Kipke heads a team that specializes in fabricating neural implants. Kipke’s group, as well as a company he leads, NeuroNexus Technologies, has the capabilities to build implants to nearly any specification — different sizes and shapes, for instance, or with different surface coatings.

After implantation, researchers led by Bill Shain from Seattle Children’s Research Institute will take multiple images of tissue that will reveal how the different cells of the brain react to an implant. These won’t be any standard images, however. Shain’s lab is a world leader in a highly advanced imaging technique known as multispectral laser scanning confocal microscopy. In essence, this technique produces high-resolution three-dimensional images of brain tissue, with each different type of tissue and cell assigned a unique color.

These images will then be transmitted to the University of Houston, where Roysam’s team will run them through a sophisticated and powerful software platform dubbed FARSIGHT, which will quantify the three-dimensional cellular makeup of the brain tissue surrounding the devices by analyzing images collected by advanced laser-scanning multi-spectral microscopes. Developed by a collaborative team led by Roysam with the support of the National Institutes of Health, FARSIGHT will translate these images into data that quantifies the response of each individual brain cell and cell type to the implant.

Researchers at RPI then take over. Using advanced pattern recognition software and techniques, professors Kristin Bennett and Mark Embrechts will seek to identify the properties of the implants that spur the brain to isolate them, as well as which implant properties seem to hinder this process. Using this information, they will suggest design changes to the researchers from the University of Michigan, restarting the whole process. What’s more, the data from all different implants and images will be collected and, as the project moves forward, analyzed to discover improved principles for neural implant design.

With four research teams from four institutions, this is clearly an intricate and involved process. Roysam stressed, however, that each contributing group is among the world leaders in its respective field. Ideally, this combination will allow the team to make great strides in the understanding of neural implant failure.

“We are fortunate to have the combination of best-available technologies in our group,” he said. “This is all high-end stuff. Dr. Kipke’s group in Michigan is a leader in the field of neuroprosthetic devices. Dr. Shain at Seattle is a leader in neuroscience and 3-D multispectral tissue imaging. The FARSIGHT system is uniquely suited to analyzing images of brain tissue. Drs. Bennett and Embrechts at RPI are leaders in building pattern recognition systems that can handle high-dimensional data. This is a unique combination, and we know how to work together.”

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