In the mid-1980s, Ronald Reagan sparked a media storm with his now-infamous Strategic Defense Initiative. It was a multi-billion dollar defense program, coined “Star Wars” by the media, because it proposed the future of America’s anti-missile defense system was putting lasers in space. His vision of futuristic, earth-orbiting laser weapons rode on the promise of “surgical precision”—the laser as lightsaber against the Soviet threat.

Of course, the SDI never happened. Reagan’s ambition was ridiculed as unrealistic and unscientific. It was too much like George Lucas’s space opera to be believable.

The irony is that no one ever questioned whether or not lasers were actually “surgically precise.” As Cornell science and technology studies professor Rebecca Slayton explained in a 2011 article, weapons-grade lasers at the time were, in fact, unwieldy, and quite bad at being precise. Lasers had become a metaphor for precision, and the public imagination ran away with the idea without questioning where it came from.

But there’s actually a double irony here. When we talk about surgical precision, we also take for granted that surgery is precise. And we imagine that one of its most extolled branches—surgery of the brain—must be the most meticulous and (sorry) laser sharp.

The truth is, neurosurgery is relatively primitive compared to other areas of medicine. When surgeons cut into brain tissue, they can’t be certain of how their patient will think and behave after the operation. Each cut can be millimeters away from destroying a patient’s ability to speak, hear, move, or feel. And despite years of news articles boasting yellow fMRI blotches as evidence that your amygdala lights
up when you look at photos of your dog, we still don’t know enough about the brain, nor the technological tools we need to navigate it.

And many neurosurgery roadblocks are, in fact, technological. With that in mind, I visited Cameron Piron of Toronto-based tech company Synaptive Medical. His company believes it has the answer to neurosurgery’s technological woes. Their proposed solution puts robotics and simulation in the front seat, giving neurosurgeons tools that do the grunt work for them, while accelerating their training with a simulated brain that’s as close as it gets to the real thing.

“There are very segmented, siloed technologies in neurosurgery, and that makes it very difficult for a surgeon to then integrate everything together,” explained Piron, the president and co-founder of Synaptive Medical. Imaging tools like MRI, for planning a surgery beforehand, are developed and distributed completely separately from the the optical tools doctors use to observe the surgery as it actually takes place.

For the last five decades, the age-old magnifying lens has been the standard optical technology in neurosurgery. Surgeons can either wear surgical loupes (a pair of glasses with magnifying lenses, first used for surgery in the 1870s), or they can use a large microscopic arm that hangs above the patient’s head. The arm includes a set of binoculars at eye level that let surgeons see what they’re operating. Based on the position of the binoculars, a surgeon might be forced to operate at awkward angles in positions that would make ergonomic designers go stress-bald. Sometimes a quarter of the operation is spent simply adjusting the microscopic arm’s position, as the surgeon reaches deeper levels inside the brain—about as precise as 1980s laser weapons.

Now, picture an operating table facing two big screens, displaying images of the brain laced with curving rainbow bands. In place of a manual microscope, there’s a robotic microscope arm. The arm aligns itself to the surgeon’s workspace in the brain, and projects the live video of the surgery in progress on the screen ahead. That’s the operating room at Synaptive where I performed my first simulated brain surgery.

“When we first entered this field, we were focused on the ability to create these networks, these maps of neural structures, and really provide an opportunity to a surgeon to navigate these structures for specialized surgical approaches for patients,” explained Piron, whose background is in magnetic resonance physics. “As we delved out into the field, we realized there are even bigger and more pressing problems.”

Those problems led Synaptive to develop BrightMatter Drive, the robotic arm with its automated microscope and light source. It also spawned their approach to diffusion tensor imaging software—a method of brain imaging that visualizes the bundles of fibres that course through the brain, and helps surgeons plan the best route for operating without cutting important connections.

Oh, and they’ve also developed a fake test-surgery brain. It looks like the head of a crash test dummy, complete with a snap-on, drill-able skull. Under the “bone” is a white mass of anatomically correct cerebral cortex. It even has four resectable tumours. Chemists and materials scientists on the Synaptive team worked to simulate the experience of performing neurosurgery, down to the tactile experience of living, wet brain tissue. It’s a level of simulation that’s almost eerie.

I remember my first medical school brain dissection, peeling away bundles of white matter that came off like a cheese string, forming the swatches of axons that linked vision with memory with language in a person who used to see and speak and remember. It’s hard not to get metaphysical when you forget the lab manual and realize that the brain in your hands held all of a person’s experiences and memories. Sure, there are Latinate names for the twists and turns of cortex, but when you’re in there, it’s overwhelming how much we don’t know.

Of course, I haven’t touched a living brain. Brain-touching is a privilege reserved for the few (with the ten or more years of training). The texture of a living brain is nothing like the mushroom firmness of my formalin-soaked specimens. So when I reached into Synaptive’s simulated brain, I was surprised at how much it felt exactly like jello. I probed into the translucent white tissue as the brain imaging screen prompted the angle and depth of my movements. A circle for targeting my next move; a command to advance the probe...
15.3mm deeper. I got to the tumour in about five minutes.

I’ve pressed and peeled the remains of real brain tissue, thinking hand-wavy thoughts about what that tissue did when it was living—but there’s a disconnect you feel when you can slide your whole finger into a groove of translucent white jelly that feels like a real brain but has never given rise to consciousness. Obviously, Synaptive’s brain simulator wasn’t developed to inspire philosophical reflections in the user. But it happens to fill a big gap in neurosurgical training. Typically, surgeons practice surgery on a grape before getting to the real living thing. Having a tool that looks and feels like a brain seems like a good bridge.

The experience of the surgery itself, as a performance, was also something I hadn’t felt before. As I positioned my probe, watching the neuroimaging screen to align it, and checking the microscope’s video feed to see the tumour, I realized every person in the room could watch what I was doing. Usually neurosurgeons are the only people in the room who can actually watch the operation. There’s a power that comes with that exclusivity (and I could talk for days about asymmetrical power dynamics in medicine)—but on the flip side, there’s an incredible levelling effect when that exclusivity gets taken away.

“It’s a totally different scenario in the operating room. It’s more collaborative,” said Piron, who has observed surgeries that used Synaptive’s tech. What’s most striking is the realization that the patient on the operating table can also watch the surgery in progress. My shaky hand, the simulated brain tissue that bounces back a bit when I touch it—it’s all up on the screen facing my simulated patient. Many neurosurgeries are conducted with patients awake, to monitor whether they lose major functions when surgeons manipulate specific parts of brain. Now, as patients listen to the surgical banter, they can also participate as gloved hands move inside their own head. They can watch their own brain as it generates their experience of watching their own brain.

For one of the most primitive branches of medicine, neurosurgery and brain science are still some of the most exciting. Just seven years after Reagan announced his Strategic Defense Initiative, George Bush Senior designated the 1990s the “Decade of the Brain,” which promised cures for Alzheimer’s and schizophrenia—another presidential exercise in overestimating scientific potential. Still, the enthusiasm for brains has remained well beyond the millennium, bringing in new developments, and their accompanying track of pop neuroscience.

“It seems like it’s always going to be the ‘Decade of the Brain,’” Piron laughed. “I can’t imagine the decade of ‘Not Being the Brain.’”

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