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A 3-D View of the Brain

Imaging software combines data from several imaging technologies to create an interactive 3-D map of the brain.

By Brittany Sauser

Researchers at Thomas Jefferson University Hospital, in Philadelphia, have developed software that integrates data from multiple imaging technologies to create an interactive 3-D map of the brain. The enhanced visualization gives neurosurgeons a much clearer picture of the spatial relationship of a patient's brain structures than is possible with any single imaging methods. In doing so, it could serve as an advanced guide for surgical procedures, such as brain-tumor removal and epilepsy surgery.

The new imaging software collates data from different types of brain-imaging methods, including conventional magnetic resonance imaging (MRI), functional MRI (fMRI), and diffusion-tensor imaging (DTI). The MRI gives details on the anatomy, fMRI provides information on the activated areas of the brain, and DTI provides images of the network of nerve fibers connecting different brain areas. The fusion of these different images produces a 3-D display that surgeons can manipulate: they can navigate through the images at different orientations, virtually slice the brain in different sections, and zoom in on specific sections.

Currently, physicians typically view the images produced by MRI technologies individually, and they conceptually visualize what the images might look like combined. "Before this type of software package, I would put up an fMRI image and put up a regular MRI of the brain and try to match the two in my brain to try to get a 3-D sense of the right spot to make an incision," says Ashwini Sharan (http://www.jeffersonhospital.org/gw-cgi/gateway_appjhs_inner.cgi/?url=f%3D5041.html&formaction=http%3A%2F%2Fwww.jeffersonhospital.org%2Fcgi-bin%2Fphysiciandirectory%2F%2F%2F%2F%2Fsearch.cgi%5E&shw=phys&id=3bbdcf&ohp=0&hos=0&affiliation=&specialty=&qids=3bb), a neurosurgeon at the Jefferson Comprehensive Epilepsy Center.

There are some other software packages that allow a technician to take a single image and render a 3-D structure, says David Andrews (http://www.jeffersonhospital.org/gw-cgi/gateway_appjhs_inner.cgi/?url=f%3D5041.html&formaction=http%3A%2F%2Fwww.jeffersonhospital.org%2Fcgi-bin%2Fphysiciandirectory%2F%2F%2Fsearch.cgi%5E&shw=phys&id=5f5f&ohp=0&hos=0&affiliation=&specialty=&qids=5f5f&recNum), a neurosurgeon at Thomas Jefferson University Hospital. However, he says, no software package can take multiple images and provide as stunning a 3-D view of the tumor-fiber interface as the new software.

With the new software, surgeons are able to see the depth of the fibers going inside the tumor, shown as dashed lines, and the proximity of those on the outside, shown as solid lines. The lines are color-coded based on their depth; they range from dark red, which represents the deepest, to dark blue, which represents the shallowest.

In addition, the team of developers at Thomas Medical College, led by Song Lai, an associate professor of radiology and the director of MRI physics, built a light-oriented surface model to efficiently cast shadows from the fibers and further improve a physician's ability to see the spatial relationship between the tumors and fiber tracks.

Having an interactive 3-D structure of the brain could be a critical tool for neurosurgeons in several ways. During a surgical procedure to remove a brain tumor, doctors must be careful not to tamper with the surrounding tissues, such as the fiber tracks that are vital to brain function. With the 3-D image, the surgeons could better understand the location and proximity of those fibers in relation to the tumor.

The new imaging also provides neurosurgeons who deal with disorders of the electrical systems of the brain with the ability to precisely determine the location of implanted electrodes used to monitor brain electrophysiological signals; such signals help physicians find the epileptic lesion to be removed by surgery. With the new software, electrodes can be accurately and automatically mapped.

Bruce Fischl (http://www.nmr.mgh.harvard.edu/martinos/people/showPerson.php?people_id=56), an assistant in neuroscience at Massachusetts General Hospital, says that the idea is "interesting" but cautions that there are a number of levels of ambiguity when talking

about connectivity in imaging. "Just because you live next to the Mass Pike doesn't mean that there is an exit," he says.

Lai's group is continuing to fine-tune the technology, and he expects it to be in operating rooms within the next year. It will initially be used for epilepsy and brain-tumor surgery, but "its ability to show the spatial relationship between structures of interest makes it general enough to be used for anything," says Lai.

Three-dimensional navigation plays a significant role in the work of neurosurgeons, says Sharan. "I know where I am going in 3-D space, and this [new software] is just leveraging that ability. That is why I am excited about something that should have been here 10 years ago."
