Nouchine Hadjikhani

Streamlining Neuroimaging

By Dustin Driver

Dr. Nouchine Hadjikhani reads minds. As a radiologist at the Martinos Center for Biomedical Imaging at Massachusetts General Hospital (MGH), a teaching hospital affiliated with the Harvard Medical School (HMS), she seeks through the use of MRI to unravel the mystery of migraines and to understand how people perceive and process body language.

Hadjikhani recently started using NeuroLens, a powerful Mac-only 3D neuroimaging application, which she runs on a Power Mac G5 desktop system and which has become a vital tool for her research. "I look at everything I do with NeuroLens," she says. She currently uses NeuroLens to get an almost instant preview of her functional MRI results before doing additional analyses using established UNIX packages like FS-FAST and Freesurfer.

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From Positron Emission to MRI

During her post-doctoral work in Sweden, Hadjikhani used positron emission tomography to scan the visual cortex of the brain. It was the first time she got to peek into someone's head. "I was trying to understand how vision and touch are connected," she says. "When you put your hand in your pocket and you feel your key, you know which one it is even though you don't see it. The question was, how can you visualize what you feel with your hand?"

In 1995, she had her first encounter with MRI. "That was quite something," she says. "I was in the magnet myself and they showed me an image of my own brain. It was a very impressive moment. Suddenly you can have somebody alive and look at different things in the brain. There's no danger and you can repeatedly get data about how the brain is organized."

She now uses her skills in her role as an assistant professor in radiology at HMS, where she has been working since 1996. Her knowledge of the visual

At a Glance

Radiologist Nouchine Hadjikhani studies migraines and the way the brain perceives body language at the Martinos Center for Biomedical Imaging at Massachusetts General Hospital, a teaching hospital affiliated Harvard Medical School. She uses NeuroLens, a powerful Mac-only 3D neuroimaging program, to view and analyze MRI scans before using UNIX programs like FS-FAST and Freesurfer for detailed data analysis. With the application running on a dual-processor Power Mac G5, she now has a quick, reliable way to preview her scans.

Using QUOSA to Track Down Research Materials

When Hadjikhani wants to know what her contemporaries are up to, she turns to QUOSA. The program enables her to quickly search and download full journal articles in PDF form. She searches directly in PubMed, and with one click QUOSA retrieves all of the full articles she has selected, automatically integrating with Harvard Medical School's vast library of research publications.

QUOSA can also automate full-article retrieval from OVID and other databases. Once the articles have been downloaded, QUOSA automatically indexes them for further searching. From there, Hadjikhani can use Boolean and proximity search to pinpoint the information she needs.

With one click, she can also create records for all of these articles in EndNote, including an automatically inserted link to the saved PDF retrieved by QUOSA. "It's a very valuable tool for research," says Hadjikhani. "I don't know what I would do without it."

QUOSA's new integration of Mac OS X

cortex and expertise with MRI machines would lead her to one of the most mundane, yet mysterious, of human ailments: the migraine.

Using MRI to Study Migraines

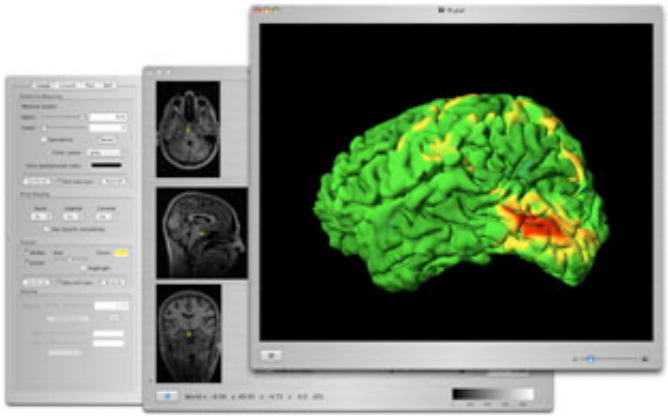
Most migraines arise without warning, but about 10 percent of migraine victims see flickering lights, called scintillations or aura, 20 minutes before an attack. Hadjikhani's task was to capture some of these auras using MRI. Luckily, she had a patient who could reliably induce an aura and the following migraine — by playing basketball. "We have a little court next to the lab," says Hadjikhani. "He agreed to play for us. We rushed him into the magnet and started to image. It was one of the first times that anybody had seen a migraine in an MRI."

The image was surprising. Hadjikhani and her peers now think that migraines with aura are triggered by a phenomenon called cortical spreading depression. Essentially, something lights a fuse that sets off a cascade of neural fireworks in and around the visual cortex. Hadjikhani and others believe that cortical spreading depression leaves chemical fallout that aggravates the meninges, which contain a network of nerves and blood vessels that surround the brain. This fallout may trigger migraine pain.

In the future, Hadjikhani's migraine work could lead to drugs that squelch cortical spreading depression. "There's evidence that if you use drugs that stabilize the neural membrane you can actually diminish migraine with aura," she says. "Right now they are anti-epileptic drugs, but they're a bit too strong and may have many side effects. Now the way is open to develop drugs that really look at the source of the problem and not the consequences of it."

Reading Bodies

Hadjikhani also studies the brain's perception of facial and body expressions. What part of the brain recognizes fear, aggravation or anger in someone's stance? Hadjikhani and Dr. Beatrice de Gelder, a colleague at Tilburg University in the Netherlands, are trying to find out.



"There are more people looking at faces now and the amount of literature is amazing," says Hadjikhani. "But you don't normally see a face alone, you see whole bodies."

Hadjikhani and de Gelder compiled a complex library of body expressions — the first one ever — to use in their experiment. Using MRI, they discovered that the same chunks of gray matter — the amygdala and fusiform cortex — are responsible for processing both facial and body expressions.

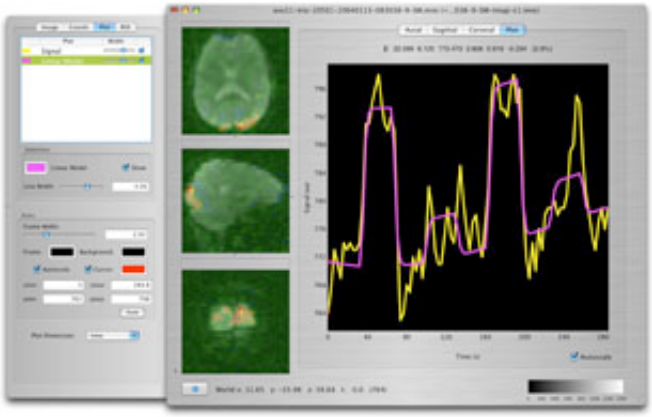
The information will come in handy for doctors who are studying autism, Williams syndrome, Huntington's disease or Parkinson's disease — patients with those ailments have trouble telling the difference between a grimace and a coy smile. "If you can't recognize facial expressions, how bad are you at looking at body expressions?" asks Hadjikhani. She doesn't have the answer yet, but she hopes that her research will lead to new treatments and therapies.

Next page: *Accelerating Time to Results*

Nouchine Hadjikhani

Accelerating Time to Results

Prior to using the Mac for viewing MRI scans, Hadjikhani viewed brain scans on Linux workstations that were developed by HMS to work specifically with the school's MRI scanners. Although the systems were great at analyzing data, Hadjikhani was challenged by the command-line interface.



Now she views all her MRI scans with NeuroLens on a dual-processor Power Mac G5 before delving into extensive data analysis on her Linux systems. The program can deliver brain images orders of magnitude faster than her Linux system and allows her to pinpoint problems with her scans almost instantly. "The first time I saw NeuroLens on the Mac I was so shocked," she says. "Normally it would take several days before I could look at the results. Now I come back from the scanner with a CD loaded with files and put it in the Power Mac computer and click on NeuroLens and in less than 10 minutes I have the results."

A Versatile and Easy-to-Use Application

NeuroLens is a powerful instrument in Hadjikhani's toolkit. It makes quantative physiological neuroimaging, a procedure that's as complicated as it sounds, nearly transparent. The program was written by Dr. Rick Hoge, a researcher at Massachusetts General Hospital and faculty member of the Harvard Medical School Department of Radiology. Hoge studies cerebrovascular physiology with MRI and knows firsthand what researchers need from an imaging program. The processing operations in NeuroLens are implemented as easy-to use plugins. The program is loaded with a bundle of standard plug-ins for data analysis, but researchers can write their own plug-ins using a built-in Xcode template (Xcode is the Integrated Developer Environment included with the Mac OS X operating system). And if scientists want to delve into the backbone of the program, the UNIX APIs are available.

"That's the thing that I like about NeuroLens," says Hadjikhani. "It's transparent in what it's doing and you have control of different things that you can visualize. It's very simple to use, but it still lets you play around and fine-tune things."

The application can also handle multiple MRI file formats, including DICOM, MINC, Analyze and AFNI. That means researchers like Hadjikhani can use NeuroLens much as a graphic designer uses Adobe Photoshop, converting one file format to another for use in other imaging programs like FS-FAST and Freesurfer. NeuroLens images can be easily dragged into Microsoft Word files or email for presentations.

NeuroLens can also track brain activity over time and display the resulting information in a variety of graphs for deep analysis.

"It's so much more convenient now that everything is on one system. There are lots of little things that make life much

Hadjikhani's Toolkit

Hardware

- Dual 2GHz Power Mac G5 with 2GB of memory
- 20- and 23-inch Apple Cinema Displays

Software

- Mac OS X
- NeuroLens
- FS-FAST
- Freesurfer
- InStat
- QUOSA
- Adobe Photoshop
- Adobe Illustrator
- Microsoft Word
- Microsoft PowerPoint

easier."

Hoge is working with scientists and researchers like Hadjikhani to refine the application and add new features that will make MRI imaging even faster. "It's a nice collaboration because he understands what the typical user needs," says Hadjikhani.

One Platform for Both Productivity and Research Tools

Hadjikhani, a longtime Mac user, was thrilled when she learned that she could use her Mac for more than just word processing and Internet research. With the rock-solid, high-performance Power Mac G5 she can tackle MRI data as well. "It's so much more convenient now that everything is on one system," says Hadjikhani. "There are lots of little things that make life much easier." Dual Apple Cinema Displays, for instance, provide the expanded desktop environment that allows the doctor to run several programs at one time. She can easily go back and forth between manipulating MRI images, checking email and composing a research paper.

As tools for neuroimaging become more advanced and user friendly, researchers like Hadjikhani can be less reliant on having to know UNIX to be effective in their fields. "It is not easy," she says, referring to UNIX. "I'm an M.D., not an engineer. Using UNIX at the command line is time consuming and you have to remember a number of things. It's nice when you can skip it." By using powerful and accessible GUI programs like NeuroLens, she can devote more time to research without the technology getting in the way. "We can learn about our results so much faster," says Hadjikhani.