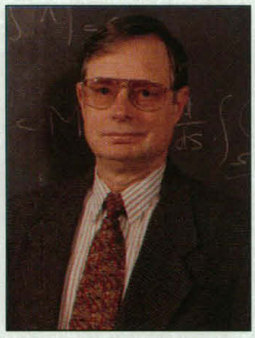
tute of Medicine. "Both applied and basic research programs can be evaluated meaningfully, and on a regular basis," concludes the panel in a report issued on 17 February, for which six federal agencies anted up $300,000. The tricky part is devising the right yardsticks, says the panel, chaired by Phillip Griffiths, director of the Institute for Advanced Study in Princeton.



Outside advice. Phillip Griffiths heads COSEPUP.

The panel, which met with agency officials after they had prepared their first performance plans to accompany last year's budget request, endorses the use of outside experts. It would be an expanded form of the peer review process that judges individual proposals, with reviewers looking at the quality and relevance of an agency's entire research portfolio. "The research needs to be done well, worth doing, and able to stand up to international comparisons," says panelist Morris Tanenbaum, a former chair of AT&T Communications. The report suggests that one agency serve as a focus for research supported by many agencies, such as global change or information technology, to make sure that national goals are also being addressed. In particular, the report notes that most R&D agencies played down their training roles when writing up their plans. "The defense and energy departments train the majority of engineers and physical scientists in this country, but those agencies are downsizing and nobody's picking up the slack even though there is heavy demand by industry in some sectors," complains panelist Mildred Dresselhaus of the Massachusetts Institute of Technology.

Academy officials would like to follow up this week's report with a longer study that Congress proposed in legislation passed last fall. It invites the Office of Science and Technology Policy (OSTP) to contract with the Academy "to develop methods for evaluating research programs," including knowing when to pull the plug. The exercise is also contained in a Senate bill (S. 296) that would double federal R&D spending by 2010.

The study has been blocked by White House objections, however. In a 7 October letter to the Senate Commerce Committee, OSTP Director Neal Lane explained that the Results Act already "provides the correct framework for developing performance goals for federal [R&D] activities" and that the new study "would depart from the GPRA approach by mandating alternative forms of evaluation." Agencies can now request permission to use nonquantitative measures, but some Administration officials see the proposal as an attempt to skirt the current law by substituting Academy criteria for those approved by the White House.

Not so, says Michael Lubell of the American Physical Society, one of many professional organizations lobbying hard for the measure. "The Academy study would provide additional options for evaluating research in a way that Congress could use to judge the success or failure of programs," he says. "Nobody wants to scrap GPRA, but scientists tend to worry when somebody other than an expert in the field tries to judge the quality of their work."

–JEFFREY MERVIS

* Evaluating Federal Research Programs www.nas.edu

COMPUTER SCIENCE

New Interface Makes Virtual World Tangible

When you explore or manipulate an object in the real world, it helps to use your hands as well as your eyes. Handling a flexible plastic film, for example, requires sensing small pressure variations across the finger tip. Inserting a pin into a small hole can require real-time information about friction and vibration. In the virtual world of computer models and remote-control robots, users generally lack such tactile, or haptic, feedback, which makes delicate manipulative tasks even more difficult. Now physicist Ralph Hollis and graduate student Peter Berkelman, of Carnegie Mellon University's Robotics Institute in Pittsburgh, have developed a new way to bring the sense of touch to computer interfaces: a magnetically suspended joystick that allows a user to manipulate—and feel—objects in the virtual world.

It's not the first haptic interface ever constructed, but it is the first to rely on magnetic levitation instead of conventional bearings, which eliminates friction and allows the device to reproduce more subtle tactile feedbacks. "It's quite an impressive interface," says haptics researcher Edward Colgate of Northwestern University, who tested the device when it was unveiled last November at a haptics symposium.* "You get the complete sensation of both motion and physical interaction in a very real way." Next May, the device will be shown in action at a robotics conference in Detroit.

It works by harnessing the Lorentz force, an effect discovered in the 19th century in which a wire carrying an electric current and immersed in a magnetic field experiences a force at right angles to both the current and the magnetic field. The force can be used to suspend a current-carrying object between two magnets—what Hollis calls Lorentz levitation. It can also cause the suspended object to move when the current flowing through it is changed.

Hollis reasoned that the right arrangement of magnets and current-carrying coils could generate force feedbacks that a user grasping the suspended object would sense, and he thought it could lead to a more realistic haptic interface than ones based on motors, wires, and pulleys. "In general, these types of devices haven't been able to achieve the degrees of freedom needed to manipulate an object's motion in space and they have too much friction, which doesn't allow the user to feel anything but the biggest haptic sensations," says Hollis.

To put theory into practice, the Carnegie Mellon group built a device consisting of a joystick handle attached to a bowl-shaped nonmagnetic surface that contains six wire coils. This assembly, called the flotor, is suspended in the air gap between six pairs of permanent magnets mounted inside and outside the flotor on bowl-shaped stationary surfaces. An arrangement of three light-emitting diodes (LEDs) and matching optical position sensors allows the device to sense motion in the flotor.

See me, feel me. An arrangement of magnets and coils creates a computer interface that can generate tactile feedback.

When an operator moves the joystick, each LED-sensor pair records movement in both the *x*- and *y*-axes around that sensor. Combining the output of the three pairs gives six independent measures of movement, corresponding to the six degrees of freedom—*x*, *y*, and *z*, plus pitch, roll, and yaw—needed to describe the motion of any object manipulated in space. Software, analogous to but far more complicated than the device drivers used to translate the motion of a trackball to movement of the cursor on a computer screen, translates the sensors' electrical output into movement of an object in a

* 17th annual Symposium on Haptic Interfaces for Virtual Environments and Teleoperator Systems, sponsored by the American Society of Mechanical Engineers, Anaheim, California, 19 to 20 November 1998.

CREDITS: (TOP) RANDALL HAGADORN/INSTITUTE FOR ADVANCED STUDY; (BOTTOM) PETER J. BERKELMAN

three-dimensional computer simulation of, for example, a bolt being fitted into the correct hole on a jet engine or a drug docking with its receptor.

The interface transmits haptic feedback to the user when output from the computer simulation alters the currents flowing to the six coils, generating forces and torques on the joystick. Crash a virtual object into a virtual wall, for example, and you would feel the impact and recoil through the joystick.

The technology allows only a limited range of motion: 15 to 20 degrees—about 2.5 centimeters—in all directions for the current device. "To get a larger range of motion you need a bigger flotor, and that would require much bigger magnets, so the device would get cumbersome," says electrical engineer Blake Hannaford of the University of Washington, Seattle. "But no device is going to be perfect, and Ralph's is very good."

The next challenge is to improve the software so that the device can interact with a wide range of computer simulation programs. "What we want to create," says Hollis, "is software that is application independent," much as it is for a mouse today—software that would allow a user to simply plug in the haptic interface and touch the virtual world.

—JOSEPH ALPER

Joseph Alper is a writer in Louisville, Colorado.

CANADA

Planned Chiropractic Merger Riles Faculty

OTTAWA, CANADA—The tape-recorded message on the phone at the Canadian Memorial Chiropractic College (CMCC) explains that chiropractics is a "science and an art and a philosophy. It's about hands-on healing." But several scientists at Toronto-based York University say it's none of those things. And they have enlisted prominent medical researchers from around the world to help them fight a planned affiliation between CMCC and York, Canada's third-largest university.

> "They should affiliate with a medical faculty ... to learn the techniques that will help them become more scientific."
>
> —Michael De Robertis

Last May, York's governing senate approved in principle a plan to offer an undergraduate degree in a field that relies on spinal manipulation, rather than drugs or surgery, to treat disease and improve health. A major component of the arrangement would be a $16 million classroom facility built by CMCC on land leased from the university. Officials view the deal as an opportunity for the university, which lacks a medical school, to expand its presence in the health sciences. "More and more, chiropractics are part of an overall approach to health," says York's associate vice president for research, Brock Fenton.

But opponents say that keeping company with chiropractors will have the opposite effect. "Surely this kind of affiliation will badly influence our academic reputation," says chemistry professor Deithard Bohme. Last fall, the university's Faculty of Pure and Applied Science voted against affiliation by a margin of more than 2-to-1, and in recent weeks faculty members have gathered support from such scientific luminaries as Stanford's Arthur Kornberg and Dana-Farber Cancer Institute's Beruj Benacerraf, who have signed onto a statement that "the affiliation would serve to legitimize the unscientific and even antiscientific philosophies and practices associated with chiropractic."

> "We believe that the body [has] the inherent ability to heal itself, and we assist the body by manipulation of the spine."
>
> —Jean Moss

That hostility already has forced York officials to abandon a plan to make chiropractors members of the pure and applied science faculty. They are now considering creating either a stand-alone entity for chiropractors or one that includes all health-related disciplines. But one leading critic, physics and astronomy professor Michael De Robertis, believes that idea is also flawed because the university doesn't have the expertise to exercise proper oversight of chiropractic training. "They should affiliate with a university with a medical faculty to learn the techniques that will help them become more scientific," he says, adding that other disciplines "started out being equally voodoo" before becoming respectable by adopting scientific methods.

CMCC President Jean Moss dismisses the controversy as a "hangover from 20 or 30 years ago" and says that recent articles in reputable journals make a strong case for the contribution of chiropractors to a patient's overall well-being. "As an institution, we believe that the body does have the inherent ability to heal itself and that we do assist the body by manipulation of the spine."

The heated debate could come to a boil next month at a meeting of the faculty senate, where four panels are ironing out details of the planned affiliation on issues ranging from curriculum to research. Opponents want the university's president, Lorna Marsden, to convene an independent group to examine chiropractic's scientific merits. A spokesperson says Marsden has no plans to do so, saying it would circumvent last year's vote. Bohme says he will introduce a motion for such an external review if Marsden declines to act.

Chiropractors are generally trained in independent schools offering a 4-year program, and half the provinces in Canada and most U.S. states recognize chiropractic care in patient health plans. Yet there remains considerable controversy about the efficacy of treatment. A recent editorial in the *New England Journal of Medicine* by Paul Shekelle of the Los Angeles Veterans Administration Medical Center (8 October 1998, p. 1074) says chiropractics has been shown to provide "somewhat effective symptomatic therapy for some patients with acute low back pain" but that it is inappropriate "as a broad-based alternative to traditional medical care."

CMCC failed in attempts earlier this decade to link up with three Canadian universities. Moss says the stumbling blocks were unrelated to the quality of care provided by chiropractors and included the logistical problem of absorbing 600-plus students. But provost Penelope Codding of the University of Victoria, which declined a CMCC offer to affiliate, notes that senate records of the decision include a belief that "research in chiropractic at this time is not consistent with contemporary standards of university research." A spokesperson for Calgary University, which also weighed affiliation, says president Terry White "cannot comment" on the school's experience with CMCC.

York's Fenton contends that the union will strengthen the university through greater diversity. "You have to be broad-minded about what goes on in universities," he says. But critics don't buy that argument. "It's irresponsible of York to do this," says Montreal-based pediatric practitioner and McGill instructor Murray Katz, who has criticized chiropractics as an expert witness in coroner's inquests and civil lawsuits. "It's a treatment in search of a disease."

—WAYNE KONDRO

Wayne Kondro writes from Ottawa, Canada.