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The Body Bionic

Table of Contents

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Building a Better Body

Information technology, overwhelmingly ubiquitous and vastly powerful, is fueling enormous strides in biomedical research. UC Irvine scientists are at the forefront, developing systems and devices that will provide mankind with a healthier, smarter, nimbler and safer future.

An Ear to the Future

by Anna Lynn Spitzer

Twenty-seven-year-old UC Irvine graduate student Tiffany Chua was born with Pendred's Syndrome, a hereditary metabolic condition that causes severe hearing impairment. She is one of nearly 300 million people worldwide with moderate to profound hearing loss in both ears. Had she been born today, Chua could have received cochlear implants, tiny electronic devices surgically placed into the inner ear to stimulate the auditory nerve. And should she have deaf children, the cochlear implants available to them will outperform by far the current technology, due in large part to the work of Calit2-affiliated UCI researchers.

Encoding Auditory Information

The cochlear implant consists of two pieces. An external speech processor with a tiny microphone, which picks up, amplifies and digitizes sounds, is worn behind the ear. The resulting signals are sent electromagnetically to a receiver implanted under the skin, where the signals are converted to electrical impulses that stimulate the auditory nerve.

The first commercial cochlear implants approved by the FDA in the mid-1980s were rudimentary by today's standards. "Basically, they just helped the recipients lip-read better," says Fan-Gang Zeng, professor of otolaryngology who is researching ways to improve the devices.

Today, cochlear implants provide most of their 100,000 users with sound that is crisp enough to allow telephone conversations.

(continued, page 2)

"I think the next big advance in hearing is going to come out of UCI."

pictured above: The cochlear implant's microphone/speech processor is worn externally; the receiver, which converts signals to electrical impulses that stimulate the auditory nerve, is embedded under the skin behind the ear.

photo, page 1:

"It turns out there is something that cell phones do pretty well that cochlear implants do not."

Researchers often refer to them as "bionic ears." The devices use electrodes to do the work of missing hair cells that, in a hearing person, convert sound into electrical impulses. The average human ear contains 3,000 rows of these hair cells; the ultimate cochlear implant would contain one electrode for each of these missing cells.

But the cochlea is only the size of a fingertip, giving researchers little room to navigate.

Nanotechnology Boosts Output

The earliest devices contained only one electrode. Now, without increasing the size of the implant, scientists using microtechnology have designed devices containing 22 electrodes. Zeng believes within the next decade, nanotechnology will enable researchers to build 1,000-electrode devices, giving the brain a 50-fold boost in the number of electrical impulses it receives from the implant.

In addition, Zeng says, a single device will one day combine cochlear implant and wireless technology. "Everything could be merged onto a single ear-piece device," he says. "Not only could you get telephone signals, but it would have a directional microphone that could pick up one voice and block out all others in a noisy environment. That would be very helpful for normal-hearing people as well as the hearing-impaired.

Investigators are looking for the answers in cell-phone technology. Patients with cochlear implants have a hard time identifying pitch, Zeng says, making it difficult for them to distinguish between men's and women's voices. "It turns out there is something that cell phones do pretty well that cochlear implants do not," he says. "We're trying to adapt that for the implants."

UCI ear and skull-base surgeon Hamid Djalilian is working on a different idea: a probe-like device, surgically implanted directly into the auditory nerve, which bypasses the hair cells. "That could give us better ability to get higher fidelity sound," he says.

These devices have another potential application: enhancing hearing for the non-deaf to a super-sharp level. Using ultrasonic sensors, scientists could decrease the frequency of very high-pitched sounds, converting them to those that humans could decipher. "This could help soldiers identify threats quicker," says Zeng.

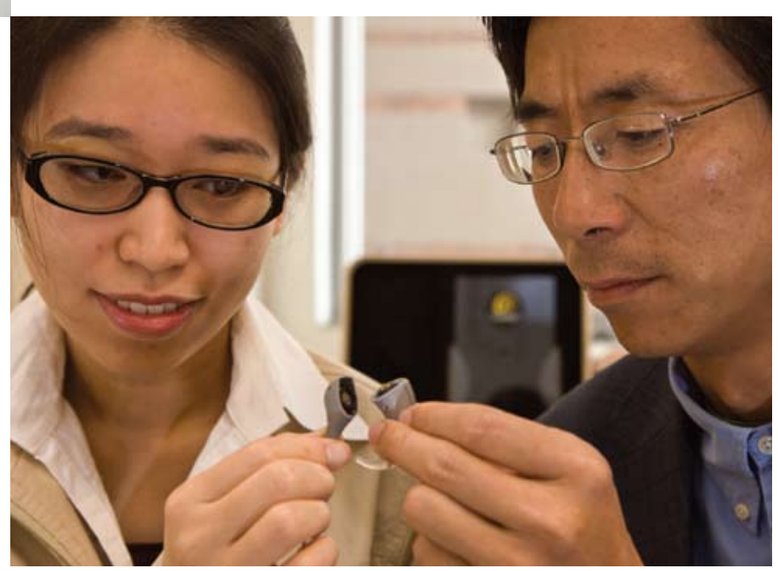
Djalilian believes the multidisciplinary research team is headed in the right direction. "We're at the forefront," he says. "I think the next big advance in hearing is going to come out of UCI."

"I think the technology is already available. The challenge is: how do we adapt the interface for medical applications?"

"I think the technology is already available," he adds. "The challenge is: how do we adapt the interface for medical applications?"

Seeking Solutions

One person searching for those answers is Chua, a doctoral candidate in biomedical engineering, who was also a 2006-07 Calit2-Emulex graduate fellow. Her personal experience with hearing impairment led her to cochlear implant research, and as a member of Zeng's research team, she focuses on signal processing to improve speech perception in users. "There is a lot to be done," she says. "Good-performing patients can hear well in quiet, but listening in noisy situations is still a challenge."



Chua (left) and Zeng focus on improving signal processing and speech recognition in the devices.

Biomedical engineering graduate students Mark Merlo (left) and Nick Gunn sport two versions of the XSense external appliance.

A Sense of Purpose

It was once science fiction. Without using sight or hearing or sophisticated equipment, soldiers on the battlefield sense an approaching enemy and know instinctively that danger is near. They have XSense, the ability to perceive objects that cannot be detected using their other senses.

Researchers in UCI's Integrated Nanosystems Research Facility are leading the effort to help humans develop this sixth sense.

XSense (eXtra SENSory Engineering) is rooted in "sensory substitution," the idea that nerves that govern specific senses can substitute for one another if they receive appropriate stimulation.

"You could hardly have someone walking around with a giant Sony Cam on his head or a Dell computer on his back,."

The concept works because of the brain's plasticity, its ability to adapt to the absence or deterioration of one of our senses by rewiring itself. Thus, people missing a specific sense can be trained to compensate by developing other senses. A blind person learns to "read" by using his hands to feel Braille letters and a deaf person "hears" by using his eyes to read lips.

"In this case, instead of restoring lost senses, we are trying to create a "sixth sense," says lead researcher Mark Bachman. "To restore vision, you can try to stimulate the optic nerve; to restore hearing you can get at the auditory nerve, but what nerve do you tap into to get infrared vision?

Substituting Senses

"Because of the principles of sensory substitution, you don't have to; you can stimulate other nerves instead that can trigger people to develop that sixth sense."

Researchers are building an apparatus that contains sensors and electrodes. The sensors in the device will detect heat or movement, causing them to deliver a stimulus – heat, vibration or sound – to a specific nerve. That stimulus is converted into appropriate electrical impulses that the brain can be trained to recognize, prompting it to "feel" an object it cannot see.

With millions of nerves in the human body though, which ones can be tapped to send the necessary messages to the brain?

The answer will arrive through trial and error. "We start with the nerves that are easiest to get to," says Bachman. "We still have to understand how we are going to take this information and deliver it to a human being so he can learn it."

Because the mouth contains many nerves and is easily accessible, researchers are experimenting with a dental appliance that will provide sensory input to the tongue and roof of the mouth.

They are also working on two versions of a bone-conduction device that vibrates the skull with low-frequency sounds: one version is implanted into the bone behind the ear; the other is integrated into a head covering, a common baseball cap, for example.

Technology Provides Solutions

The project is powered by IT. "You have to map the sensory stimulus into something the brain is going to be able to interpret and you can't do that without using a computer," says Bachman. "To go after this goal in a serious way was not even possible until recently because computers and sensors have not been small enough until now. You could hardly have someone walking around with a giant Sony Cam on his head or a Dell computer on his back," he grins.

"Now the sensor technology is so much smaller. With a device the size of my thumb, I can have all the power of a vast PC."

Building Better Balance

"I've fallen and I can't get up." The oft-mimicked tagline to an old advertisement underlies a problem faced by many elderly and infirm: poor balance.

More than 90 million Americans older than age 16 have experienced dizziness or balance problems. Balance-related falls account for more than half of accidental deaths and 75 percent of emergency room visits in the elderly population.

UCI researchers are working to allay this dangerous condition on two fronts.

Implantable Prosthesis

One approach is to build a balance-replacement device known as a vestibular prosthesis. Using MEMS (Micro-Electro-Mechanical Systems) technology, Calit2 affiliate Andrei Shkel is constructing a tiny system-on-a-chip that will be implanted to replace a damaged balance system.

The 4x4-millimeter silicon chip contains sensors – gyroscopes for measuring rotation and accelerometers to detect motion – and a circuit system that translates this information into electrical pulses. The pulses activate implanted electrodes that stimulate the vestibular nerve to send the necessary information to the brain.

Shkel's research group is building the sensors and electrodes; they are collaborating with School of Medicine faculty, who will determine the best surgical procedure for implanting the device.

Getting the device to market is still several years off. Shkel, associate professor of mechanical and aerospace engineering, hopes to have the complete system-on-a-chip prototype within three years, follwed by testing on animals and humans.

The MEMS device might also be used one day to enhance the balance system of pilots and elite athletes. "Our physiology is not designed to respond fast enough to certain motion changes. This chip could apply additional electric stimulation to the vestibular nerve, creating 'super-humans,'" Shkel says.

Wearable and Functional

In addition to this implantable device, researchers are developing an external balance-augmentation tool that incorporates sensory stimulation and feedback to retrain the brain to provide balance.

Balance problems can be caused by inner ear organs or nerves in the legs that aren't functioning properly. While stimulating the respective nerves is one approach, it requires invasive surgery and is not yet perfected.

Stimulating Substitute Nerves

Instead, sensory substitution – the theory that nerves can substitute for one another if they are stimulated properly – underlies a different approach. Bachman and Djalilian are using patients' skin as a stand-in for the balance nerves.

If a person with normal balance is tilting too far to the right, explains Djalilian, the information about tilting to the right side is sent by the inner ear to the brain, which recognizes that and self-corrects. In a person with

(continued, page 6)

Shkel's vestibular prosthesis for restoring balance contains sensors and a circuit system.

compromised balance, that information does not get to the brain, so "we have to give them that information using other stimuli such as vibration," he says.

They are designing a sensor-and-electrode-loaded fabric that will stimulate nerves in the skin when a patient begins to fall.

As the person begins losing balance, accelerometers in the fabric sense that motion, relaying the information to a computer. The computer activates electrodes that stimulate specific nerves with heat or vibration. Those signals are processed and sent to the brain, which then alerts the patient that he is beginning to fall.

Currently, the sensors and stimulators are hooked up to a computer that processes the sensor information and sends a signal back to the stimulator. Eventually, both functions will be integrated onto chips, according to Bachman, and a prototype device could be ready for testing in the next couple of years.

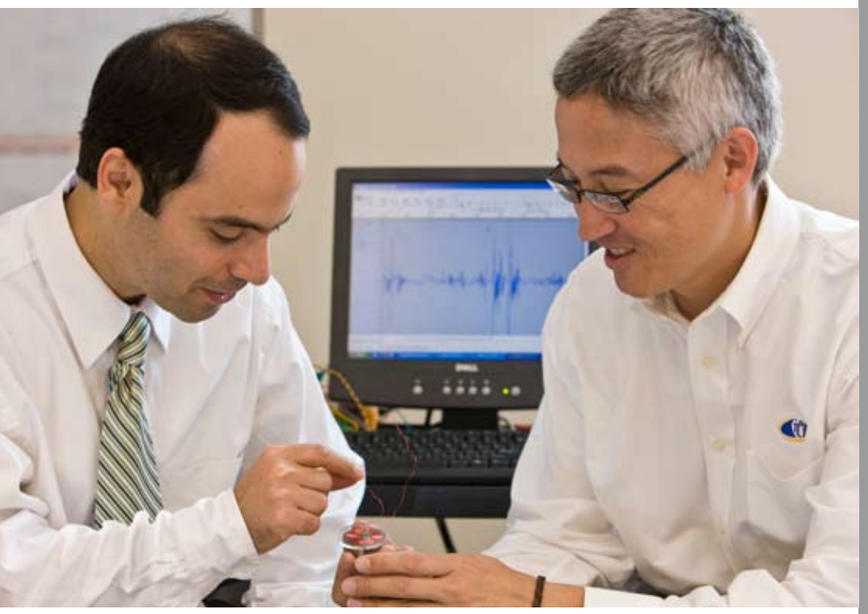
Two iterations of the fabric are being tested. One is a patch worn on the patient's thigh; the other is a lightweight vest worn next to the skin.

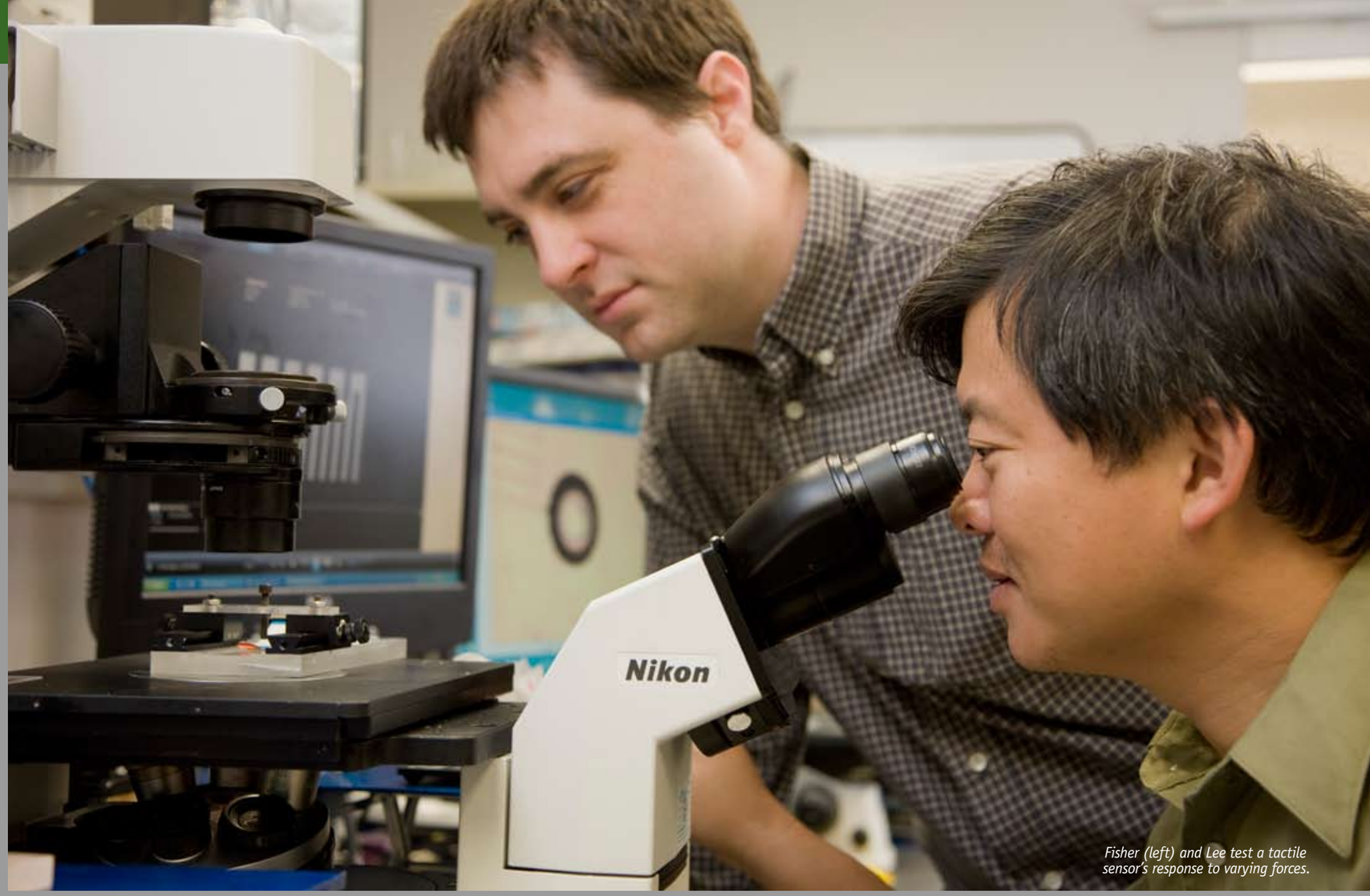
Researchers also are experimenting with pressure sensors, built into the soles of shoes, which operate on the same principle.

Researchers are designing a sensor-and-electrode-loaded fabric that will stimulate nerves in the skin when a patient begins to fall.

The challenge, of course, is that the information must be sent on its way instantly. "It has to be very real-time processing. If there is lag time, the patient will fall before the brain receives the message," Djalilian says.

Djalilian (left) brings his clinical expertise to research; Bachman calls himself "the gadget guy."





Fisher (left) and Lee test a tactile sensor's response to varying forces.

Touching Progress

It's a far cry from the claw-like apparatus dangling from Capt. Hook's arm. Today's technology is making possible innovative aesthetic and functional improvements in prosthetic limbs.

A sophisticated prosthetic hand is under development at UCI, part of a nationwide effort funded by DARPA to construct a bionic arm that is wired directly into the nervous system. This neural wiring will allow amputees degrees of motor control and feeling that were previously unattainable.

UCI is one of 30 organizations, including 10 universities in Canada, Europe and the United States, working on phase two of "The Revolutionizing Prosthetics Program," which intends to make these advanced devices available by 2009.

Existing prosthetics are either purely cosmetic or somewhat functional, but not both, according to Bill Tang, professor of biomedical engineering. Tang and his group participated in phase one of the project, investigating artificial muscles that could power the prosthesis and allow it to move with the ease of a natural arm.

They experimented with a pressurized-gas hydraulic system that could better mimic muscle function than motors, pulleys and gears. This system is also quieter, smoother and more flexible than a motor-and-gear system, Tang says.

When completed, the prosthetic device will imitate the force, agility and multiple degrees-of-freedom of a natural hand. It also will interface directly with the user's nervous system. A team led by James Fallon, professor emeritus of psychiatry and human behavior, also participated in the first phase of the project, securing the neural probes onto the user's peripheral nerves so that a signal from the nerve could control the hand's movement.

Infusing Tactile Sensitivity

Remarkably, the hand will also possess a tactile sensing system that will allow it to discern temperature, texture, pressure and degrees of hardness, as well as

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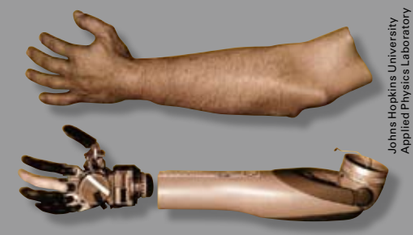
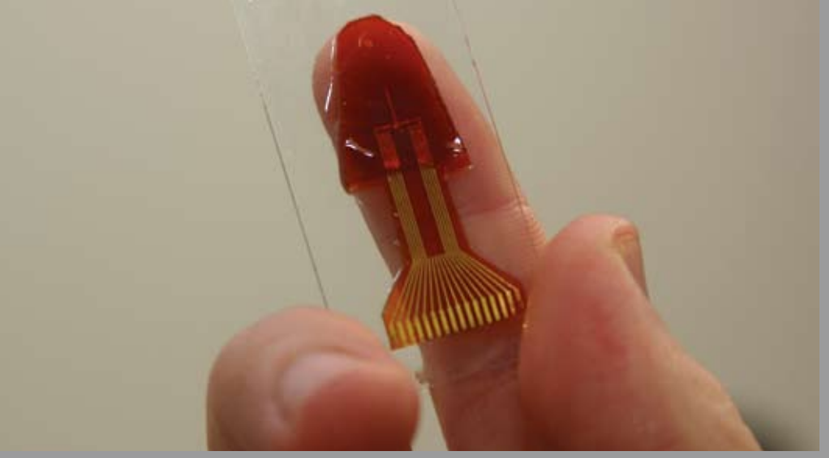


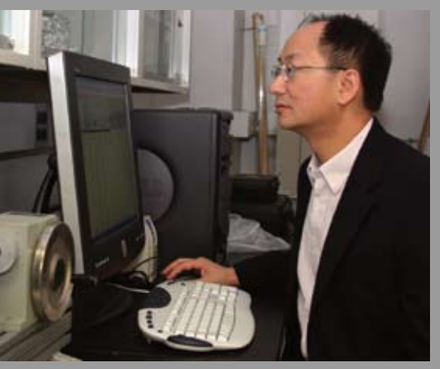
Johns Hopkins University Applied Physics Laboratory

The DARPA prototype includes a natural-looking artificial covering developed using photographs of the patient's native limb taken before the accident.



Tactile sensors in the prosthetic arm will one day allow users to pick up an egg, use a screwdriver or shake hands.

Tang studies data indicating stress and strain when force is applied to an artificial muscle.



perform social functions like shaking hands or gesturing. "Human touch is very sensitive and a lot of that has to do with multi-modal sensing," says Abraham Lee, biomedical engineering professor and leader of the tactile research component. "Our ultimate goal is to get to that level, where we give the user the overall sense of the human hand."

Three different types of sensors are being fabricated on a common platform and integrated into a skin-like covering. One measures pressure, another vibration – both by way of microfluidics, the movement of fluid through tiny channels – and the third senses proximity of objects to the limb by detecting the electric field around it.

A human hand uses multiple types of receptors simultaneously when performing functions like using a tool or holding a hot cup of coffee. Doctoral candidate Jeff Fisher assembled a behavioral chart that spells out which senses and what combination of sensor functionalities are required to perform specific tasks.

Tool manipulation, for example, requires the ability to sense graduated pressure, slippage, position, location, orientation, movement and curvature. Each of these requirements necessitates a different combination of sensors.

IT is the messenger that keeps the components communicating. "We not only need to send information to the robotic hand to control it, but we also need to get information back from it," says Tang. "Think about picking up an egg. A human can sense how much force he is exerting on the egg. But for the robotic arm, we need to have that tactile information sent back to the controller so it can manage the amount of force the robotic fingers are exerting."

"Think about picking up an egg . . ."

Adds Lee: "What we are ultimately trying to do is connect the brain to the senses, to the nerves, to the neuron firing and then connect those to our sensors so the user will have the same sensation as with a human hand. That's where IT really comes in."

Igniting Technology is sponsored by Knobbe Martens Olson & Bear LLP in partnership with the University of California, Irvine division of the California Institute for Telecommunications and Information Technology.

Join us Thursday, May 15, 2008
5:30-8:30 p.m.
Calit2 Building, UC Irvine

- **Discover next-generation sensors impacting prosthetic capabilities**
- **Experience "XSense" – going beyond sight, hearing, touch, taste, smell**
- **Glimpse the future of implantable devices**
- **View IT-powered tools of tomorrow that will transform human potential**

Presenters:
- **Fan-Gang Zeng (see page 1)**
- **Mark Bachman (see page 4)**
- **Jeff Fisher (see page 8)**
- **Bob Molinari, biotechnology venture capitalist**

www.regonline.com/BionicHuman

Crossing OVER

Researchers Draw on the Arts to Advance Literacy and Ethical Behavior

by Anna Lynn Spitzer

The second graders practicing a line dance or performing a skit certainly are having fun. What they probably don't realize is that they're improving their literacy skills at the same time.

As they follow their teacher's directions to reach high, leap sideways or speak loudly, they're sharpening their knowledge about verbs and adverbs, and strengthening their cognitive ability.

And when they listen to and discuss specifically chosen stories, they are developing skills in empathy and ethical behavior.

Thanks to a new project called "ArtsCore: K-2," 7,000 kindergarten-through-second-grade students who probably wouldn't otherwise have access to arts education will receive it – along with the complementary language arts and decision-making skills – courtesy of UC Irvine's Center for Learning through the Arts and Technology (CLAT).

Previously known as the Center for Learning through the Arts, CLAT sought to add a technology component to its programs. Late last year the center formally affiliated with Calit2, subsequently winning the $828,000 ArtsCore grant. Funded by the California Postsecondary Education Commission, the project will help San Diego Unified School District K-2 teachers learn to

(continued, page 10)

First-graders create a character from the book "Who's in Rabbit's House?"

integrate art and ethics education into their classroom teaching.

Visiting Artists Share Expertise

The project will fund professional dancers, painters and actors to make weekly visits to selected schools and co-teach standards-based arts lessons with the classroom teachers. Twelve teachers in each of five SDUSD schools will participate each year of the three-year program – a total of 180 teachers in 15 schools.

"We're not only trying to expose children to the arts because it's a wonderful part of life, but to fashion the program so they're also learning cognitive skills that will put them ahead in other parts of the curriculum," says Liane Brouillette, CLAT director and project PI.

Budget cuts have reduced or eliminated visual and performing arts programs across the state, Brouillette says. She and her staff have chosen low-performing schools in underserved neighborhoods to participate in ArtsCore. "In wealthier neighborhoods, the PTA pays or parents pitch in to bring arts education into the schools," she says. "We are trying to give these other schools the same quality of arts instruction."

ArtsCore focuses on training classroom teachers to use the arts to coax new literacy skills out of their young charges. "You can teach the arts but unless you make explicit the academic connections, they remain unrecognized and maybe untaught," says Kim Burge, CLAT director of educational outreach.

Crafting Imagination

In the first year, the visiting artist and the teacher work hand-in-hand. Together, they attend workshops where they learn to recognize the literacy strands and thinking skills in each of 27 visual arts, drama and dance lessons they will co-teach.

"The visiting artist and the classroom teacher work together to create a richer environment," says Brouillette. "It is very much a collaborative effort."

In the second year, classroom teachers are supported by the school district's visual/performing arts resource teachers, and, ArtsCore developers hope, by the third year, they can teach the lessons alone.

Throughout the program, teachers also will learn how to utilize literature to help the children improve their ethical and moral decision-making. Co-PI Kristen Monroe, UCI professor of political science and philosophy, and director of the Center for the Scientific Study of Ethics and Morality, has researched methods for training college students to become more empathetic; now she wants to impart this proficiency to younger children.

"There are a lot of different groups of people in society; some get along, some don't and there's too much prejudice against certain groups," she says.

Using well-known books like Dr. Seuss' "Butter Battle Book" and "The Sneetches" – as well as original short stories – Monroe hopes to give children models that will encourage acceptance and ethical behavior.

"We're trying to accomplish three different things," she says. "We're trying to deal with general ethical issues, with moral dilemmas, and with getting the kids to see different groups in different ways."

Connecting the Dots

Researchers will evaluate the program's success. They will observe the participating teachers, and conduct school climate surveys pre- and post-project. "Research literature shows participating in the arts is a morale booster," Brouillette says, "and kids learn more when they and their teachers feel better about their environment."

The team also will conduct a quantitative evaluation of the program using district and state-mandated standardized tests. They will compare scores for individual children at participating schools with scores of children in a matched control group.

In addition, they will use evaluative art. Children will draw pictures of themselves and other ethnic groups, before and after the program, to see whether their perceptions have changed.

Researchers are expecting to see the connection between arts and literacy/ethical thinking that they already suspect. "We're looking at literacy in its fullest context," says Burge. "Reading, writing, listening, thinking and speaking – kids are gaining all of those competencies through the arts."

Practicing a movement exercise with a teaching artist helps kids learn parts of speech.

Ask the TIPSter

***TIPS** (Taking IP to Startup) is a service offered by Calit2 to help guide faculty and students through the process of moving their research to the business marketplace. TIPSters Luis Vasquez from OCTANe LaunchPad, and Demetri Andrikos and Doug Crawford from UCI's Office of Technology Alliances, answer your entrepreneurial-minded questions.*

■ How do I get venture capital to fund my company?

First, you need a business that can grow at the speed and scale that venture capitalists need to achieve investment returns. Small markets, niche products and/or small royalty payment ideas will usually not fit the VC's financial model.

Next, you need to identify the right type of VC. Almost all VC firms focus on specific industry sectors. A few, like Okapi Venture Capital, have both life science and information science partners, but these are the exception. VC firms also focus on different investment stages. Some do seed investments (to develop the first product or prototype) while others invest in early-stage companies or later-stage companies. University-developed IP usually requires seed-stage investment.

Finally, and maybe most importantly, you need a team of people that can create and grow a successful VC-backed company. In some seed-stage ventures with terrific technology, the VCs can help create or recruit a team. However, in most cases, forming the initial team is the responsibility of the inventor.

■ How do I meet the VCs so I can show them my business presentation?

Venture capitalists usually rely on introductions through people they trust in order to select the companies they will meet. Who are these trusted advisors? They can be other entrepreneurs (or professors/researchers) who have successfully started VC-backed companies, lawyers (especially those who work with IP or early-stage companies), licensing agents from technology-transfer departments, people from groups like OCTANe that specialize in helping startups, and other service providers such as accountants, regulatory consultants, marketing consultants, etc.

■ How else can I get my idea funded for commercialization?

The further proven, validated and developed an idea is before trying to commercialize it, the more likely it will be successful. This means taking full advantage of funding from NIH, NSF, private foundations, corporations, etc. After a company is created, there are also SBIR and STTR grants *(www.sbirworld.com and www.sba.gov/SBIR)*. We are also lucky to work in an area with some of the most active angel investing networks in the country. Locally, Tech Coast Angels invests in seed and early-stage companies *(www.techcoastangels.com)*. Finally, there is your own money. Investors like to see that founders have contributed not only their time and effort but some cash as well.

You can contact one of these experts by emailing tips@calit2.uci.edu *or stopping by to get the advice you need in person. TIPS has open office hours 1-5 p.m. every Thursday and 1-4 p.m. the first and third Tuesdays in the Calit2 Building, suite 4100.*

A Universal Rhythm

Jeon selected specific drums to represent five geo-cultural regions.

by Shellie Nazarenus

The human heart beats 60-80 times per minute. The sustained repetition of the pulse – slowing and speeding synchronously with movement – results in an unrehearsed rhythmic pattern.

"As far as I know, we built the world's first telerobotic sound improvisation played by online users who live in different locations."

For electronic artist Byeong Sam Jeon, the heartbeat provides the ideal metaphor for his latest interactive project, Telematic Drum Circle.

"We may have other differences – physical, cultural, economic, political – but when it comes to the heart, everyone has a beat," Jeon says.

Jeon wondered if a traditional drum circle could be transformed by technology to form a collective global voice without a single spoken word, reflecting the rhythm at the center of our being.

Typically, drum circles are convened within communities. While some drum groups form around particular issues, others have no agenda except to allow the members an impromptu opportunity to come together, play their instruments and share rhythm.

Three years ago, soon after arriving from his native South Korea, Jeon stumbled upon a group of people casually gathered on a Chicago street corner, banging out an infectious beat with makeshift instruments. It was his first exposure to a drum circle.

"After three minutes I was participating, dancing actually, and clapping along in sync," Jeon recalls. "I was fully communicating without saying hello."

The experience was an eye-opener. Jeon's own creative voice emerged from the drumming session and ideas began flowing.

Preliminary Plans

He prepared a 20-page proposal outlining the concept for an Internet-based drum circle. He envisioned a room filled with percussion instruments, each outfitted with a robotic drumstick. Users from every corner of the world would log onto a designated Web site, choose a drum and tap together across cyberspace.

But with no studio, money or equipment, Jeon needed support. In 2006, he came to UCI as an Art Computation Engineering (ACE) graduate student and found a home in Calit2's second-floor performance technology lab.

At first, Jeon's working prototype was crudely simple – some discarded white water buckets, broken tree branches and very basic robotic technology.

"It looked really bad in the beginning but surprisingly it worked," Jeon grins. "I mean, when I think back on it, it really worked well."

Encouraged by positive feedback from his ACE colleagues and professors, Jeon put together a promotional package and called upon dozens of companies. His entrepreneurial efforts paid off.

Eight sponsors came forward, including several music and technology companies.

Remo, Inc., one of the biggest percussion manufacturers in the world, lent Jeon their products for six months. He carefully chose 16 instruments representing five geo-cultural regions, paying close attention to the pitch of each to ensure good overall sound quality.

Clippard Instrument Laboratory donated the miniature pneumatic components that utilized compressed air to make the robotic drumsticks pound when the online participants tapped their keyboards.

Several other companies supplied Jeon with various electronic components needed to complete his project.

"As far as I know, we built the world's first telerobotic sound improvisation played by online users who live in different locations," Jeon says.

Drum Roll, Please

The telematic drum circle debuted at Calit2 in February. The colorful, new instruments with their electronic devices formed a large circle in the middle of the lab. Cameras pointed at the circle from various angles, providing a live stream of video broadcast through the Web site. While participants logged on from remote locations to join the ensemble, others stopped by in person to play along from one of several laptops in the lab.

The numbers were immediately impressive. Within the first 10 days, more than 700 people visited the lab. The Web site had 11,000 page views and 4,000 online participants actually played the drums. By tracking IP addresses, Jeon determined he had international participation, with at least 27 countries represented.

People from Buenos Aires were interacting with users from Seoul, London, New York and Tokyo.

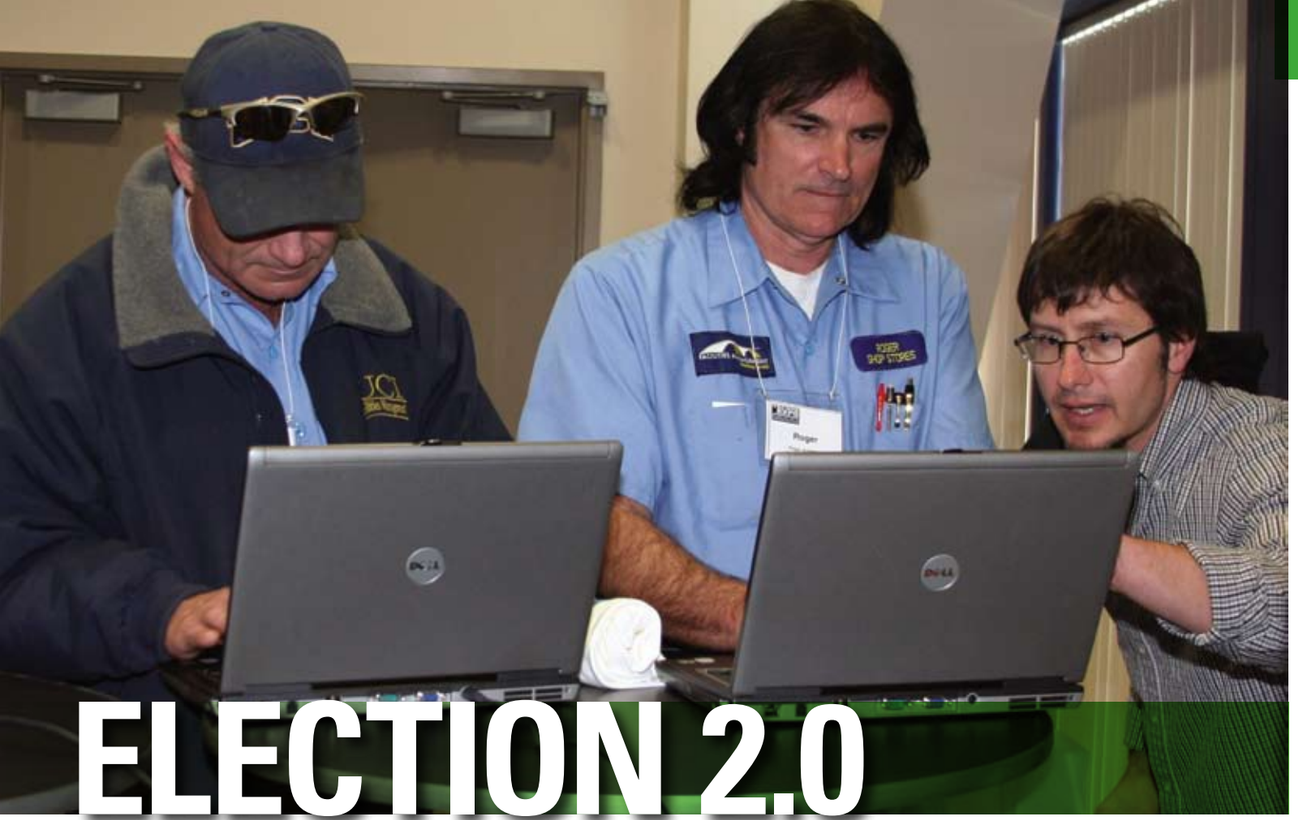
It appeared language was not a barrier. Participants found creative ways to "talk" to each other, experimenting with the sound by creating patterns and making interactive connections. "Some people used it like a Morse code exchange," Jeon says.

For Jeon, this is only the start. He plans to further refine the project by adding more instruments, robotics and archival technology so participants can preserve their experiences.

He hopes the virtual drumming will continue to facilitate deeper channels of discourse and foster a real sense of community and family.

"The heart-to-heart communication that can be expressed on these drums cuts through all the differences," he says. "It blurs the boundaries between us."

www.TelematicDrumCircle.com



ELECTION 2.0

Observations and Insights from a Virtual Voting Project

Gaulin (far right) demonstrated the site at a variety of campus venues.

by Ted Gaulin

Ted Gaulin is a doctoral candidate in political science who has a keen interest in politics and technology. He serves as political consultant for the Calit2-supported MyElectionDecision.org.

Generally speaking, the American electorate is not terribly well informed. Voters often know more about leaders' personal foibles and political missteps than they do about their policy positions. This is especially true of younger Americans, who are less politically knowledgeable and less likely to vote than other age cohorts.

Last fall, as the 2008 presidential campaign was beginning, educator and Calit2 researcher Robert Beck wondered if information technology could reverse this trend and reinvigorate political participation. Young voters, Beck reasoned, might be less politically engaged, but they are tech-savvy and strongly drawn to online communities. Beck assembled an interdisciplinary team of researchers from UC Irvine and Lawrence University in Appleton, WIS. to create an interactive Web site that encouraged voters to focus on *issues* rather than *personalities*.

The result is *MyElectionDecision.org*. Launched in October 2007, the site gives users a "blind taste" of the presidential candidates. Users complete a series of questionnaires in which they rank pressing national issues, such as the war in Iraq, healthcare and immigration. Next, they read policy statements on these issues without knowing who authored them and "score" them on a Likert-type scale, indicating their level of agreement. Our software tallies and weights this data, and presents users with their candidate preferences in rank order.

Overall, *MyElectionDecision.org* has been very well received. We've had more than 10,000 users and many positive comments. The most inspiring feedback was users commenting that they were surprised by their results and interested in learning more about a candidate they had not previously considered. To us, this indicated we had succeeded in separating the attributes of the candidates – their attractiveness, likeability, party affiliation – from their specific policy proposals. It indicated that the project design leads users to temporarily suspend their political biases and preconceptions, and see the candidates anew.

Two aspects of the project totally surprised us. The first was *MyElectionDecision.org*'s popularity with non-academic users. We had originally envisioned the Web site as a pedagogical tool in university and high school classes – a way to supplement political science and government course material. While the Web site is being used in that capacity, a full 70 percent of our users are logging-in from non-educational domains. Equally interesting is the numbers of foreign users from more than 30 different countries and on all seven continents.

The quality of dialog in the Web site's discussion forum also surprised and pleased us. Users seem genuinely interested in pursuing some of the topics that were raised in the surveys. There have been lively debates about the war in Iraq, the viability of biofuels as an energy alternative, whether Mike Huckabee's proposed flat tax would hurt the poor, and a host of other issues. Participants marshal sophisticated arguments for their views and often provide links to other Web sites with supporting data. The discussion has not degraded into the kind of flame war that often plagues online forums and seems to be in keeping with our goal of informing and educating potential voters. In one instance, a member of Ron Paul's campaign staff actually weighed in to answer a question that had been raised about his boss's energy policy! That was pretty cool.

> **"What we can say at this stage is that our data appear to be representative of national trends."**

One challenge has been keeping up with the evolving policies of the various candidates. For example, Hillary Clinton's energy proposals are much more nuanced today than they were when we first launched the Web page; so is John McCain's economic policy. Even slight changes in position require us to update the site. A similar challenge arose from the turbulence of the campaign itself. For example, on January 30th we suddenly had to strike Rudy Giuliani from our slate of candidates when he withdrew from the race. A week later we had to do the same with Mitt Romney. Then we scrambled to assemble a set of policy statements for Ralph Nader when he joined the race.

Our findings? Both political engagement and voter turnout are very high for this election, a fact that we'd love to take credit for but probably cannot. The truth is that it is too early to tell whether our project is spurring non-voters to action. We plan to conduct an extensive survey of users after November's general election to determine its impact. What we can say at this stage is that our data appear to be representative of national trends. For example, supporters of Clinton tend to rank the economy as the number one concern; likewise, Barack Obama supporters rank the war in Iraq as their top issue.

We invite readers – even those firmly committed to a particular candidate – to test drive the Web site. You might be surprised at your results!

www.MyElectionDesicion.org

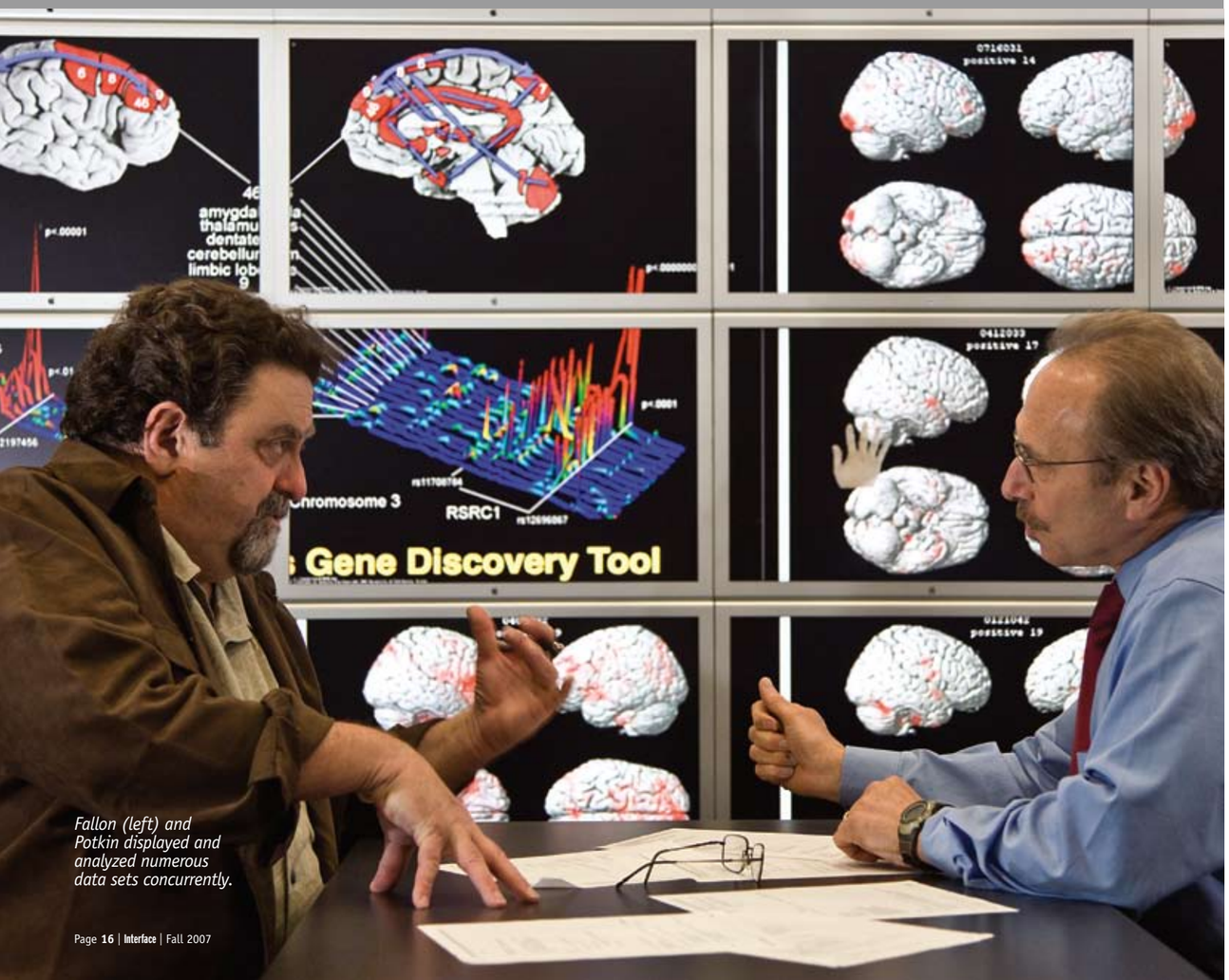
"One challenge has been keeping up with the evolving policies of the various candidates. "

a new Point of View

HIPerWall Leads Researchers to Genetic Discovery

by Anna Lynn Spitzer

Most of us can remember a six-digit computer password or even a 10-digit phone number. But give us a string of 100 numbers and the ole memory blows a gasket.



Fallon (left) and Potkin displayed and analyzed numerous data sets concurrently.

A similar – but hugely magnified – dilemma faced UC Irvine researchers Steven G. Potkin and James H. Fallon. The Calit2-affiliated professors were in the throes of solving a medical mystery: identifying the genes associated with schizophrenia, a debilitating mental disorder.

They had to examine 25,000 genes, one at a time, factoring in 200-300 variations on each that can present one million variations across the genome. (They were able to whittle the variations down to 4,000 by utilizing principles of probability.) In addition, they analyzed FMRI (functional magnetic resonance imaging) data from the participants – schizophrenics and a control group – that documented the brain's activation patterns and circuitry while the subjects performed various memory-related tasks.

The researchers were looking for the proverbial needle in a haystack of data: emerging patterns that could help them connect millions of dots into a genetic picture.

First, they had to get a grasp on the vast quantity of data.

Data Sets Come Alive

They turned to HIPerWall, Calit2's Highly Interactive Parallelized Display Wall. The 200-million-pixel, tiled, grid-based wall gives researchers a larger-than-life view of their data sets at extremely high resolutions.

There, they could scrutinize multiple data sets simultaneously, comparing and contrasting images while they rotated, dissected, spliced and superimposed them.

The wall also facilitated their collaboration with experts in a variety of fields – cognitive science, physics, informatics, computer science, neuroanatomy, statistics and genetics – who contributed crucial expertise.

"If you're going to do transdisciplinary research, you have to develop a shared conceptual framework," says Potkin, director of clinical research in the Department of Psychiatry & Human Behavior, and director of UCI's Brain Imaging Center.

"HIPerWall is a way to literally see the essence of other disciplines' findings; instead of having to try to remember so much detail, you can just look over and there it is," he says. "And the information is dynamic, so you can explore it, manipulate it and immediately see the results."

Organizing Overload

The schizophrenia research, funded by the National Institutes of Health through BIRN (the Bio-imaging Informatics Research Network), involved an intricate labyrinth of information.

Data from schizophrenic subjects' brain-activation images, brain circuitry and genetic makeup were analyzed and compared, both to others with the disease and to the control group. Simultaneously, millions of gene variations were scrutinized to see if any relationships to the brain data were evident.

HIPerWall's adaptability allowed the researchers to group data in several ways: for example, by gender, severity of illness and genotype information. They could overlay additional data simultaneously, as well as display relevant information from international databases. "We started to discern patterns that would not be obvious from the statistics alone," Potkin says, adding that those patterns could be validated by checking corresponding statistical data.

> **"HIPerWall is not replacing our statistical or mathematical tools, it's enhancing everything."**

Before high-tech visualization tools were available, researchers had no choice but to wade through millions of mind-numbing, data-generated numbers. "But with HIPerWall, people didn't want to leave our meetings," says Potkin. "Everybody was really high with creative excitement."

Fallon, professor of psychiatry and human behavior, concurs, noting that the wall "really brings a bit of the art into science.

"HIPerWall is not replacing our statistical or mathematical tools, it's enhancing everything," he adds. "It's really value-added. You get an extra boost to your entire perceptual and intuitive process."

Mission Accomplished

The wall ultimately engendered success; researchers identified two genes associated with schizophrenia and have filed a patent application to protect use of the genes for diagnosis or as targets for therapy.

Although it took about a year to gather and adapt the required information, they say the wall reduced their research time significantly. Fallon says the gene identification process occurred in an afternoon.

"We had Steve (Potkin), a psychiatrist who knew the clinical aspects of schizophrenia; we had a geneticist who knew the ins and outs of the gene patterns; we had Padhraic Smyth, who knew statistics, understood databases and developed text-mining tools; and I know the neuroanatomy. When you wrap all that together on HIPerWall, all of a sudden patterns came out very quickly. Hidden layers were revealed that allowed us to say, 'look at this!'"

The researchers are poised to launch their next project, investigating genetic risk factors for Alzheimer's disease. This time, they know that a specific gene increases the risk of contracting the disease, but there's more to the story; their job is to determine what other genetic factors are responsible.

The volume of data dwarfs their prior research. This study will include structural, metabolic and amyloid plaque brain imaging from 850 subjects. Each subject has 650,000 possible genetic variations.

"We're looking forward to having HIPerWall help us digest this," Potkin says. "It will make the work more interesting and more fun. And now that our procedures are in place, we should be able to finish in about one-tenth the usual time."

www.hiperwall.calit2.uci.edu

Innovation Goes GLOBAL

Study Reveals Complexity in International Supply Chain

by Anna Lynn Spitzer

Some of the study's results surprised Dedrick (left) and Kraemer.

Grandpa's radio has grown up. So has its production process. Electronic devices – and lots of other products as well – are becoming increasingly sophisticated. In today's global economy, the manufacturing supply chains that produce them have become equally complex.

Calit2 academic participant Ken Kraemer and two associates, Jason Dedrick and Greg Linden from the Personal Computing Industry Center at UC Irvine's Paul Merage School of Business, studied the manufacture and assembly of several electronic products in two categories of innovation: radical and incremental.

Radical innovation includes products that introduce new technologies or new ways to integrate core technology. Apple's iPods fall into this category.

Incremental innovation refers to products that evolve and improve steadily, without fundamental changes in technology – laptop computers, for example.

The team dissected the manufacturing process and assigned monetary value to the many countries around the globe that participated in making the products.

It used to be that a large company like IBM would design and develop its own merchandise, using internally produced components.

Today, most electronics companies buy parts from other companies around the world, outsource their manufacturing and sell globally through wholesalers and retailers located in major markets.

Multinational Components

The UCI research team, which is part of the Alfred P. Sloan Foundation's Industry Centers Program, began its look at the global supply chain by examining Apple's 30 GB video iPod. Researchers learned that numerous companies – and countries – profit from the product in varying degrees.

The team based its report on information from Portelligent Inc., a company that dismantled the video iPod and identified the parts' suppliers. Turns out a variety of U.S. and overseas companies combine technologies to make and assemble the 451 parts in the popular device.

The hard drive and display module were made primarily in Japan, the multimedia processor was designed in the U.S., and the mobile memory chip in Korea. But there's more: each major part is made up of many smaller pieces, which may or may not have been manufactured in the same country in which the major suppliers are located. Intermediate processing also took place overseas – the hard drive in China and the processor in Taiwan or Singapore.

The team found similar results when it studied two other iPod products, as well as notebook PCs from Lenovo and Hewlett Packard.

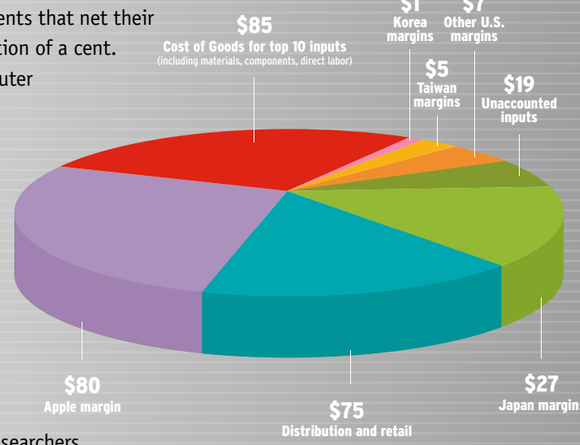
Measuring Value

The researchers built a framework to measure and map the value captured at each step of the manufacturing process. Using a formula that multiplies the part's estimated factory price by the supplier's gross profit margin, the researchers determined the value captured by the supplier and the country in which it is located. For the higher-value components, the researchers also analyzed the estimated value captured by the supplier's suppliers, especially where cross-border transactions were involved.

Researchers determined that the iPod, which sells for $299 retail, costs about $144 to make. While Apple captures the largest share of the value, netting about $80 per device, the Toshiba hard drive alone costs $73, netting the Japanese manufacturer approximately $20. The display module is also made by Toshiba, netting the company nearly $6. And so it goes, down to low-value components that net their manufacturers a fraction of a cent.

The laptop computer supply chains yielded comparable results.

While the distribution of value captured differed between companies, it did remain consistent at the national level. Researchers were surprised to learn that a very small number of companies capture most of the value in electronic products.



Regional Differences

The study indicated that "countries tend to occupy well-defined spaces in global supply chains," with innovative countries capturing large shares of value, and developing countries, which provide low-cost manufacturing and assembly, receiving very little value.

Most important, perhaps, in today's global economy, is the fact that even though many electronic products are "manufactured" in China, only a tiny percent of their value added is captured by that country. "This is important because bilateral trade statistics, which show a U.S. trade deficit with China, can be misleading if most of the value is created elsewhere," Kraemer says.

"Today, no single country is the source of all innovation and therefore, U.S. companies need to work with international partners to bring new products to market," the authors write. "This is simply a fact of business in the 21st century, and the good news is that many American companies are winning this game and continuing to bring significant benefits to the U.S. economy."

FUNDING NOTES

by Stuart Ross

Saving Power in Mobile Devices

For battery-powered mobile devices, low power consumption is always the goal, and Calit2 has received two contract awards from industry to pursue some interesting possibilities. Late last year, Qualcomm awarded UCI a contract to study power consumption in the radio reception circuitry of two types of mobile devices – GPS receivers, used widely for location and navigation, and Ultra-Wideband (UWB) receivers, which have advantages in penetration and security for very short distances. The $40,000 contract work is led by Payam Heydari, associate professor of electrical engineering. This research is an extension and application of work first presented by Heydari's group in 2006, which showed the importance of optimizing a particular ratio of circuit characteristics.

Samsung Electronics awarded a $150,000 renewal contract to Fadi Kurdahi, professor of electrical engineering, to investigate using error tolerance in some subsystems as a way to save power. Kurdahi argues that if small error rates can be tolerated in some memory arrays without affecting perceptions of performance (such as speed or brightness), then lower voltages could be used in some cases. For example, if the device is receiving a strong wireless video signal, then minor errors in the buffer memory would matter less than if the signal were weak, so the voltage to that memory array could be lowered. Such compensation mechanisms could also allow for higher error tolerance in the manufacture of some memory arrays.

Collaboration in Cyberinfrastructure

Calit2 participants are familiar with large-scale scientific enterprises supported by advanced computation and high-speed networks – we even know the word "cyberinfrastructure." But there has been little research on the actual social practices of cyberinfrastructure development. Charlotte Lee, a research scientist in the department of informatics, aims to fill that gap – she has recently been awarded an NSF grant for $150,000 on "Collaboration in the Development of Cyberinfrastructure." Her research will investigate existing scientific and engineering practices and how those practices are collaboratively transformed in the creation of cyberinfrastructure; she will identify patterns of collaboration and relate those patterns to organizational and scientific outcomes. A metagenomic cyberinfrastructure project is serving as a field site. Lee, who earned a master's degree in sociology before turning to information science, will use ethnographic methods, including participant observation and semi-structured interviews. Her findings will have important implications for the conduct of future cyberinfrastructure projects.

A New Role for Network Nodes

Athina Markopoulou has won a prestigious 'CAREER' grant from the National Science Foundation for $450,000 over five years. Her work is on 'network coding,' a relatively new approach to designing networks that allows intermediate servers to play a more active role in traffic distribution. Network coding helps to avoid denial-of-service attacks, in which malicious users overload a target server, and it permits better re-tracing of the network topology. Markopoulou will work to establish a better theoretical and experimental basis for the optimal use of this new approach.

Trust Issues in an Open Database

If you want to understand the environment of a bay or river, there are many studies available, each completed by a different sponsor and each covering some specific topic, place or period of time. A master database – including the results from all the studies by government agencies, corporations and individual scientists – would be useful. But how can you trust that the data are from reliable sources and haven't been tampered with? That's the problem being addressed by Calit2's Cristina Lopes, associate professor of informatics, Michael Goodrich, professor of computer science, and Stanley Grant, professor of chemical engineering. They received a grant of $1.1 million to develop ways to monitor the reputation of data contributors (somewhat like buyers and sellers are rated on eBay) and to tag the data to prevent tampering or misuse. Their particular study involves a watershed, but, as the NSF recognized, their results will be useful in many scientific fields, including medicine, education and astronomy.

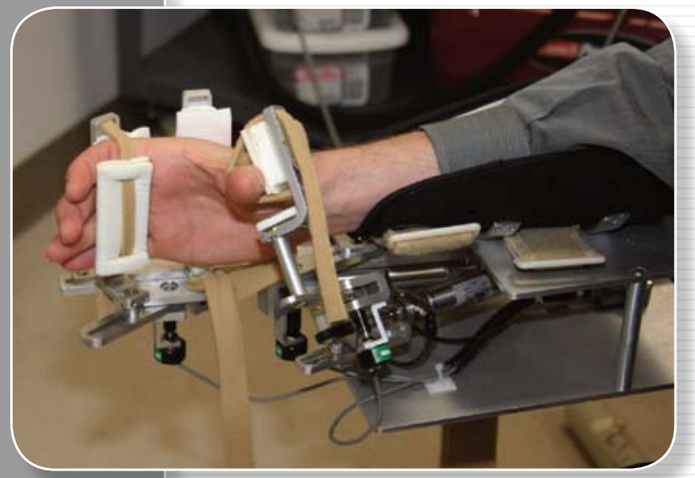
The Coming 'LifeChips'

A team led by Calit2 director G.P. Li has been awarded several government and industry contracts for an ambitious effort: establishing integrated, universal approaches to the design of medically implantable microchips. There have been many predictions about such chips, and some are already in use, but this team seeks answers to common chip-engineering problems: wireless interfaces, chemical reactions at the nano-scale, sensors and actuators designed for biological systems. Nor has there been a systematic approach to manufacturing and testing such unusual devices, so the team is also addressing those areas. The "LifeChips" program has become a major presence on campus by bringing together many different sponsors and researchers in the common effort. Funding has been secured from the UC Discovery Grant program, with matching funds from industry (Maxwell Sensors, Ceradyne, Northrop Grumman and others), and the National Science Foundation (for graduate research and education).

This list comprises recent awards administered by Calit2. The institute is particularly interested in helping faculty secure grants for IT-based interdisciplinary research. Contact stuross@uci.edu *for details.*

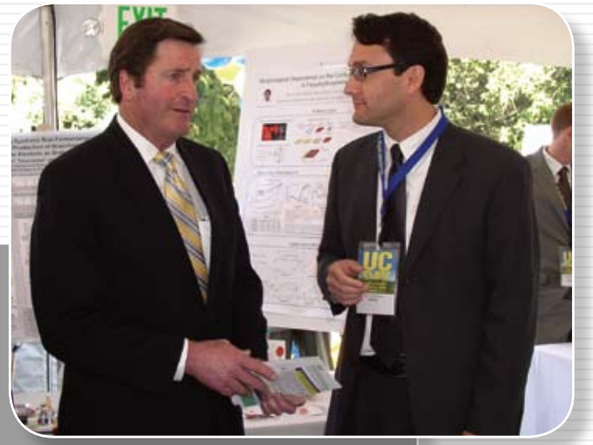
HoWARD Expands Repertoire

HoWARD, a computerized robot that helps stroke patients regain hand motor function, has spawned an offspring. The robot, developed by Calit2 affiliate Steven Cramer and associates, is currently in phase two of testing. This time, instead of simply measuring the effects of task repetition on mobility recovery, HoWARD has been programmed to stimulate separate motor areas in the brain to see how that shapes recovery. "We're trying to see if you individualize therapy for people injured in a specific brain area, do you see greater gains?" says Cramer. "It's like coming up with different flavors of robotic therapy."



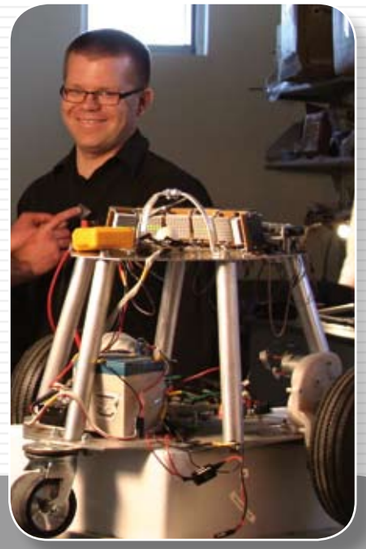
Web Site Attracts Crowd at TechnoExpo

Several hundred interested visitors attempted to end their pre-primary indecisiveness on Feb. 5 by registering on the Calit2-sponsored *MyElectionDecision.org* web site at UCI's TechnoExpo. The Calit2 booth at the expo buzzed all day as visitors lined up to investigate the site, which matches users with the presidential candidate whose views most closely resemble their own. *MyElectionDecision.org* was developed by Calit2-affiliate Rob Beck, professor of education, in an effort to learn whether technology can engage Generation Y more deeply in the political process (see page 14).



GreenScanner Takes Sacramento by Storm

California lawmakers were seeing green. UC Day, an annual event that showcases the University of California message to state legislators, this year spotlighted "Investing in Green Research and Solutions." Assistant Professor Bill Tomlinson represented Calit2's efforts, demonstrating GreenScanner, an online public database of environmental product information and opinions. After exhibiting the site's capabilities all day, Tomlinson says he was buoyed by the crowd's reactions. "Everyone seemed really excited about the project and said they would be interested in using it," he recounts.



Cockroach Robot is "Discovered"

Discovery Channel USA sent a production team late last year to film a piece on Calit2-Emulex grad fellow Garnet Hertz's cockroach-powered mobile robot. In an effort to create a pseudo-intelligent system with a cockroach CPU, Hertz's experimental mechanism uses the live Madagascan hissing variety of *la cucaracha* to control the three-wheeled robot, while infrared sensors provide navigation feedback. The segment is expected to air later this year.

Igniting Green Tech

Green-tech investing is at an all-time high and a sold-out crowd of Orange County venture capitalists, entrepreneurs and business people attended the most recent Igniting Technology event to learn more. A panel of researchers and corporate partners presented "Green" smart solutions powered by IT-based infrastructures. Attendees saw first-hand clean-tech prototypes under development, including the newest Toyota plug-in hybrid vehicle, which was delivered to UCI as part of an ongoing sustainable-mobility development research program. The next event in the panel series sponsored by Knobbe Martens LLP is scheduled May 15 (see page 8).

A Sense of Danger

Calit2 affiliate Maria Feng is directing a new research center that could help save members of the U.S. military from harm. The Center for Advanced Monitoring and Damage Inspection, funded by a five-year, $5.5 million contract from the U.S. Army, is developing new sensors and other evaluation tools to detect damage and assess the integrity of soldiers' protective armor. Feng gives special credit to Calit2 for her success in winning the contract. "The sensor work I did in the Calit2 Building enabled me to make my proposal to the Army," she says. Feng received additional recognition recently: she was named by *OC Metro* as one of 20 Orange County "Women to Watch."

University of California Research Connection

Calit2 was the backdrop for a meeting of UC research vice chancellors interested in system-wide collaboration. The group, hosted by UCI Vice Chancellor for Research Sue Bryant, visited several labs in the building, including Bill Tomlinson's Interactive Animation Lab *(pictured top)* to learn about the various projects and opportunities for their campuses to partner.

The meeting in late fall was followed a couple of months later by a visit from UC Vice Provost Rory Hume, who is interested in fostering the "Power of 10," a multi-campus research effort. Hume expressed particular interest in the collaborative technologies that Calit2 makes available, including the Zeiss Center's microscopy services *(pictured bottom)* and the HIPerWall display.

Global Attention

International visitors continue to seek out Calit2. During five months recently, scientists from nine countries spent time touring and talking with researchers in various labs. Visitors from every corner of the globe came to the institute hoping to stimulate research collaborations and understand how the institute partners with industry. For example, a delegation from England's University of Warwick *(pictured top)* toured the Calit2 building to learn more about the facility and its operations. Recently ranked "Best in the UK," the university wanted to see first-hand how partnerships such as the Zeiss Center of Excellence are maintained. Other visitors included 75 delegates from the National Academy of Engineering's Indo-American Frontiers of Engineering program *(pictured bottom)*, who viewed Calit2 and its UCI partner, the National Fuel Cell Research Center.

Telemedicine Initiative Moves Forward

The past few months have seen significant progress in Calit2's efforts to pull together a team of telemedicine researchers, medical practitioners and community clinic personnel to develop new technologies and protocols for health-care delivery. Herb Schultz, senior health policy advisor to Gov. Schwarzenegger, was guest of honor at a half-day telemedicine retreat held in the building. Other groups, such as the Irvine Health Foundation *(pictured)*, visited the building to witness up-close the models already in prototype stages at Calit2.

Ross Gains Recognition

For the past six years, Stuart Ross has led the Calit2 Irvine division's research development efforts, working tirelessly with academic affiliates to secure funding opportunities. Prior to joining UCI, Ross was the founding director of Cal State Fullerton's Office of Grants and Contracts. It was those 14 years of service that earned him recent recognition – the "Gold Star Exceptional Service Award" – as part of CSUF's 50th anniversary celebration. "I was honored and flattered to be remembered years later," said Ross, who was one of two former employees to receive the award.

More Relevant Technologies

The second annual series of courses conducted by Calit2 for the Osher Lifelong Learning Institute (OLLI) received positive feedback. The November program, "More Relevant Technologies for Living in the Future," featured research in telemedicine, emergency preparedness and sensor exploration. According to series facilitator and OLLI member George Hume, "participants considered the Calit2 classes challenging, but exciting and very informative, which is exactly what we should seek in our courses." Managed by UCI Extension, the OLLI program offers courses and events for seniors. Plans are underway for another series next fall.

Power Networking

One of Southern California's largest technology organizations has found a new home at Calit2. TechBiz Connection is holding its highly popular, monthly panel presentations in the building's auditorium. The non-profit group's mission is to support SoCal technology research, companies and entrepreneurs by providing timely education and networking opportunities, and focusing on the intersection of technology and business. Upcoming events at Calit2 can be found at *techbizconnection.org*.

Where Technology & Business Intersect
TechBiz Connection Plug In!
TechBizConnection.org

UCI Alum Discusses Knowledge Management

Scott Shaffar established Northrop Grumman Corp.'s knowledge management (KM) initiative in 1997 on the B-2 Bomber program. Ten years later, thanks to today's pervasive workplace communication technologies, Shaffar directs a company-wide KM effort. The UCI mechanical and aerospace engineering alumnus provided an interesting overview this winter to a Calit2 audience. Shaffar covered a variety of topics, including technology adoption, changes in multi-generational workforces, the shift from managing co-located teams to managing teams in virtual environments, and the impacts of physical workspaces and growth in electronic content within large corporations.

The California Institute for Telecommunications and Information Technology is a two-campus multidisciplinary research institute. In collaboration with its sister institute at UC San Diego, Calit2@UCI develops innovative projects that integrate university expertise with industry experience. The result: IT-based solutions that benefit society and ignite economic development.

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Calit2

do you wanna dance?

A participatory media exhibit designed by Calit2 EMPTe Lab Manager John Crawford, assistant professor of arts-dance, is drawing visitors this spring to the San Francisco Public Library. Using networked computers and communications technology, DANCE-IT (Dance & Information Technology) encourages observers to become participants who interact with and influence its digital media content.

The display – commissioned by the San Francisco Ballet on its 75th anniversary – offers real-time, real-space participatory contact. Visitors view one of several pre-recorded dances, each of which represents a different style. Then they create their own dance in the same style, to the same music – in the exhibit's open-walled design. The DANCE-IT system records each participant and integrates his/her movements permanently into the exhibition, creating an evolving work of public art.