interface

California Institute for Telecommunications and Information Technology

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University of California, Irvine

Picking Up Good Vibrations

interface-2-face

Continuing Collaboration

This year promises many new research initiatives focusing on leading-edge developments in all technological fields through close collaboration and teamwork. The Henry Samueli School of Engineering is proud to partner with Calit2, which provides an interdisciplinary platform propelled by faculty and students committed to advancing their research. This issue of *Interface* highlights technological advancements made by Professors Masanobu Shinozuka, Maria Feng and Pai Chou, researchers in the sensors field – a field shared by engineers and scientists from multiple disciplines.

The study of sensors – tools that can monitor and detect signals given from different sources – is a prime example of sophisticated research that has very practical applications, such as examining the structural "health" of a building or bridge. The carefully placed sensors can essentially communicate conditions and help predict future problems that may occur within an infrastructure. For example, this type of technology can report changes and movement in real time, collecting sensitive data that may otherwise be difficult to obtain, and potentially protect against damage caused by earthquakes, landslides and other destructive events.

The Henry Samueli School of Engineering looks forward to continuing and encouraging its dynamic collaboration with Calit2. Together, we will continue to develop innovative research techniques, promote faculty and student technological advancements, and provide outstanding education to graduate and undergraduate students through classroom learning and laboratory research experience.

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Dean, The Henry Samueli School of Engineering

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On the cover: *Calit2 researchers Serdar Soyoz and Maria Feng check the data log for sensors they installed on an Orange County freeway on-ramp. Sensors measure vibration, strain, displacement and soil pressure, alerting engineers to potential problems.*

2007 marks the sixth year of an innovative collaboration between Calit2 and its affiliates. The institute and its academic and industry partners have pooled brainpower and resources to pursue novel partnerships that can benefit California's economy.

Calit2 also represents collaboration between the UC system and the State of California. It is one of four Institutes for Science and Innovation created by the state specifically to sustain its global growth and competitiveness, and the first to undergo a comprehensive review.

The UC Provost formed a review panel comprised of nationally renowned scholars, business leaders and a faculty senate representative. The nine-month process culminated last fall with an on-site, three-day visit by the panel.

In its preliminary findings, the review panel saw vast potential in Calit2's role in the larger context of the university. "Because Calit2 is external to the department and school organizations, it can bring to the university useful elements that are often not well sustained in the traditional organization. It has the potential to leverage traditional research and education activities by helping to foster creativity and innovation in an entrepreneurial and multi-disciplinary environment."

Several steps remain in the review process, including a solicitation of formal comments, a unified response and a follow-up plan of action to the panel's recommendations. The final report is expected later this spring.

By all indications, however, panelists gained a favorable impression of Calit2 and its accomplishments, noting, "Calit2 has built a 'field of dreams' with exciting possibilities for the future."

Structural Scrutiny

Sensors Monitor Health of Buildings and Bridges

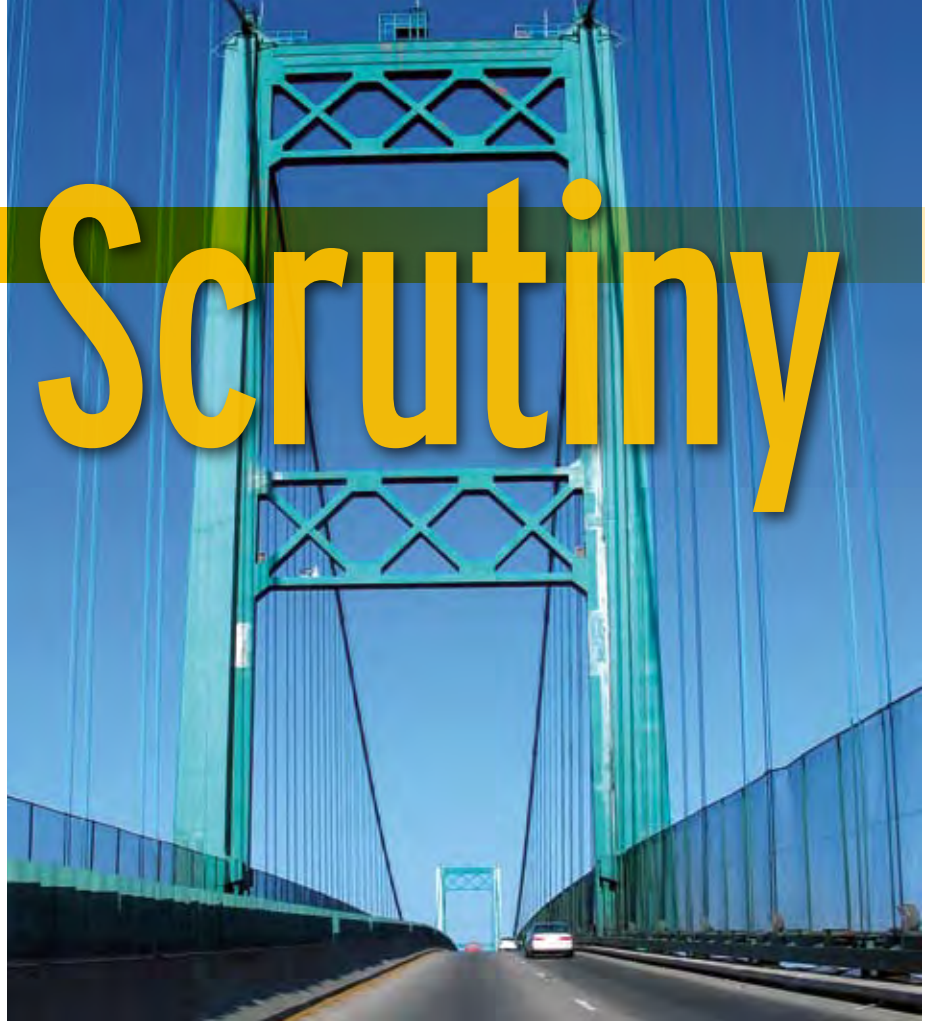


photo: Amanda Neal Hughes

Open wide and say "aaaaah."

Or, in this case, "centimeters per second squared."

In much the same way that doctors monitor their patients' symptoms to diagnose illness and prevent complications, a team of researchers uses sophisticated sensors to monitor the health of buildings, bridges and other civil infrastructures.

by Anna Lynn Spitzer

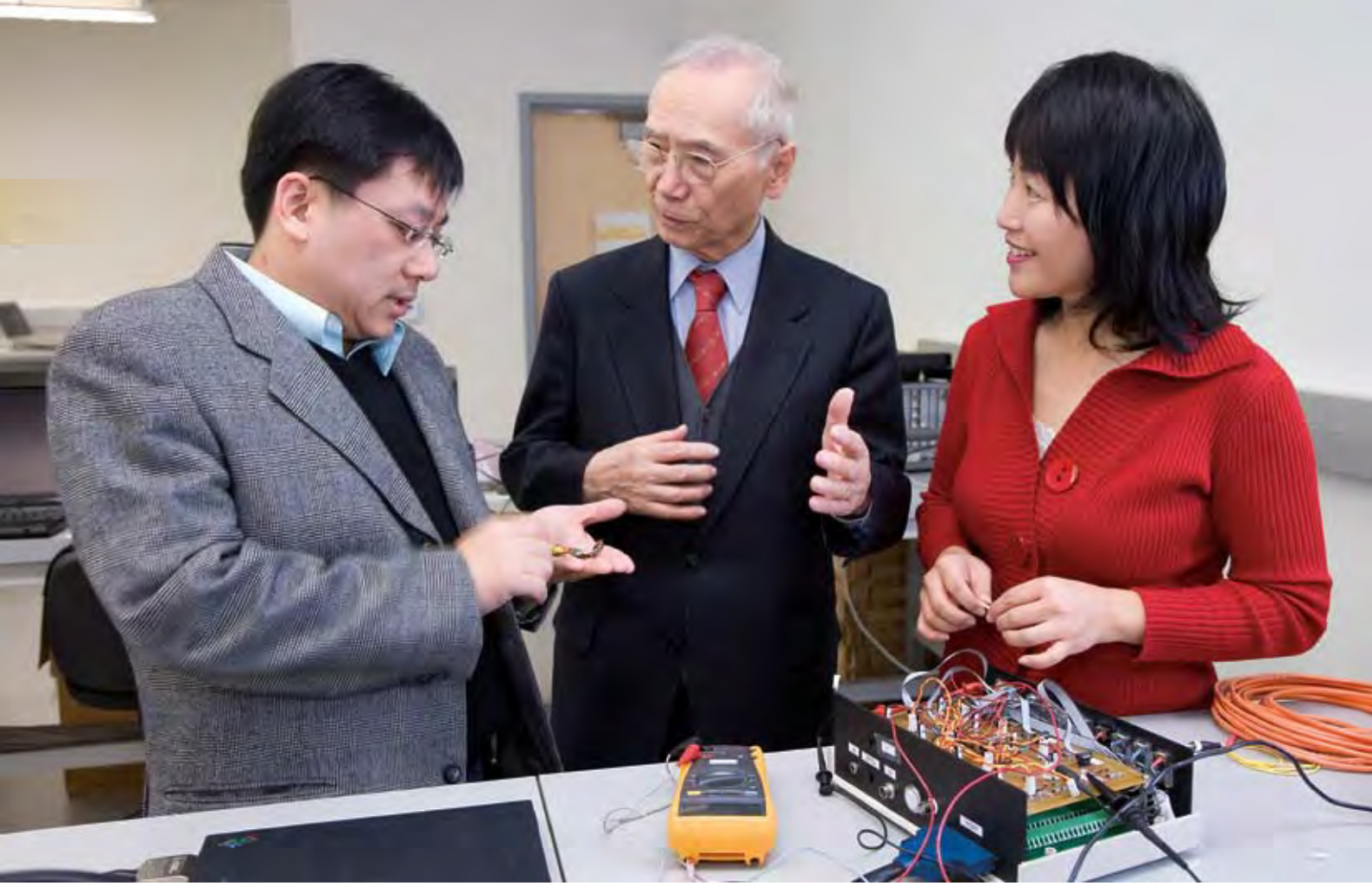
"What's so rewarding is that people in different fields are all excited and after seeing what we can do, they are asking us for more. It means we are onto something right."

Maria Feng, a UCI professor of civil and environmental engineering, is the driving force behind a novel research partnership that pairs Calit2 and the U.S. Geological Survey (see page 8). The collaboration makes the Calit2 Building the first structure in the world to utilize sensors in both the building and the ground to monitor simultaneously structural integrity and ground soil movement.

Picking Up Vibrations

While the building was under construction in 2004, contractors installed 31 USGS sensors at selected columns and beam joints, and buried 12 more in the ground outside. The sensors measure the building's vibration; change in the vibration characteristics could indicate structural weakness. The data are streamed in real time to a set of recorders in a second floor lab. Two to three times daily, the data are analyzed by a computer utilizing specialized software developed in-house to determine whether structural changes are occurring. Data can be viewed from remote locations as well; all data are posted on the Internet and stored in a database for future use.

When ground motion exceeds a predetermined level, the sensors are triggered automatically to measure



Sensors developed by Calit2 researchers (from left) Pai Chou, Masanobu Shinozuka and Maria Feng monitor a wide range of objects, from newborn babies to huge civil infrastructures.

the ground motion and structural response. The software runs to check the structure, immediately identifying potential damage that might escape human inspection.

Like people, buildings and bridges can also suffer the effects of aging. Because the building was brand new when the sensors were installed, comparing vibration measurements over time allows researchers to track changes and avert potential problems.

A Force of Nature

Feng is a petite woman with enormous enthusiasm and energy.

Born and reared in China, she was in high school when the 1976 Tangshan earthquake killed nearly a quarter of a million people. "It was very shocking," she says. "Most of the structures in China at that time were masonry buildings that didn't have much earthquake resistance."

She believes that trauma indirectly led her to her chosen field. After graduating from Nanjing Institute of Technology with a degree in mechanical engineering, she studied robotics at the University of Tokyo. "I learned a lot about vibration control and sensors. I began wondering if I could apply the same concepts to the structure system," she says.

"...this was an excellent opportunity to study important issues, like the interactions between the building and the soil foundation."

Groundbreaking Opportunity

When Feng learned that a new Calit2 Building was to be erected at UCI, she recognized a valuable opportunity. "The USGS has always been interested in monitoring earthquake ground motion," she says. "They had also recently recognized the importance of monitoring structural health. I convinced them that this was an excellent opportunity to study important issues, like the interactions between the building and the soil foundation."

Serdar Soyoz a doctoral candidate and Calit2-Emulex graduate fellow who is working with Feng, oversees data recording and analysis. He explains that "soil-structure interaction" – known to researchers as SSI – is significant because it can influence a change in vibration levels. "Sometimes soil becomes loosened and that can change the system's characteristics. The sensors in the soil allow us to factor in environmental causes like rain or drastic temperature change, which can influence building dynamics."

Vibration data is recorded on 24 channels, each of which reflects a specific group of sensors. The data base is comprised mostly of ambient vibrations – those that occur on a regular basis and are caused by traffic, nearby building construction and other day-to-day movement. It also contains readings from two moderate

(continued, page 5)

New Frontiers in Sensor Exploration

From monitoring bridges to testing preemies to tracking eating habits, sensors are being employed in novel and sometimes surprising ways at Calit2@UCI.

Wireless Sensors

Masanobu Shinozuka, UC Irvine Distinguished Professor, and chair of the Department of Civil and Environmental Engineering, and colleague Pai Chou, associate professor of electrical engineering and computer science, collaborated on a MEMs-based wireless sensor called DuraNode. The sensors are powered by sun, wind or rechargeable batteries. Because they don't require a supplementary power source – often lacking in remote areas – they can be used almost anywhere.

The DuraNode is small and reasonably inexpensive, and can relay information from one sensor to another. Currently in the proof-of-concept phase, the DuraNode will begin field tests this spring on the Vincent Thomas Bridge.

Shinozuka is also in talks with the Irvine Ranch Water District about placing multiple DuraNode sensors on pipes in the underground water distribution system. "In an earthquake, the system is at risk and if pipes broke, you wouldn't necessarily know where breaks occurred," he said. "These inexpensive sensors can be used to identify those breaks almost instantaneously by looking at changes in sensor response."

Video Sensors

Shinozuka is also researching mobile video-based sensors that can be used on unusually large or inaccessible structures. A combination high-powered telescope and video camera, the sensor can be mounted 100-200 meters from its target. It focuses simultaneously on pre-selected points; software with unique real-time image processing algorithms identifies the movement of the points, giving researchers an accurate measure of displacement.

> **"It is quite difficult to make them so tiny without sacrificing performance."**

These sensors passed a recent test on the Vincent Thomas Bridge, providing Caltrans with data they were not able to obtain by traditional means.

"That was a very difficult location to access, so it was a perfect application," Shinozuka states. "Caltrans was very pleased with the results."

Eco Nodes for Infants

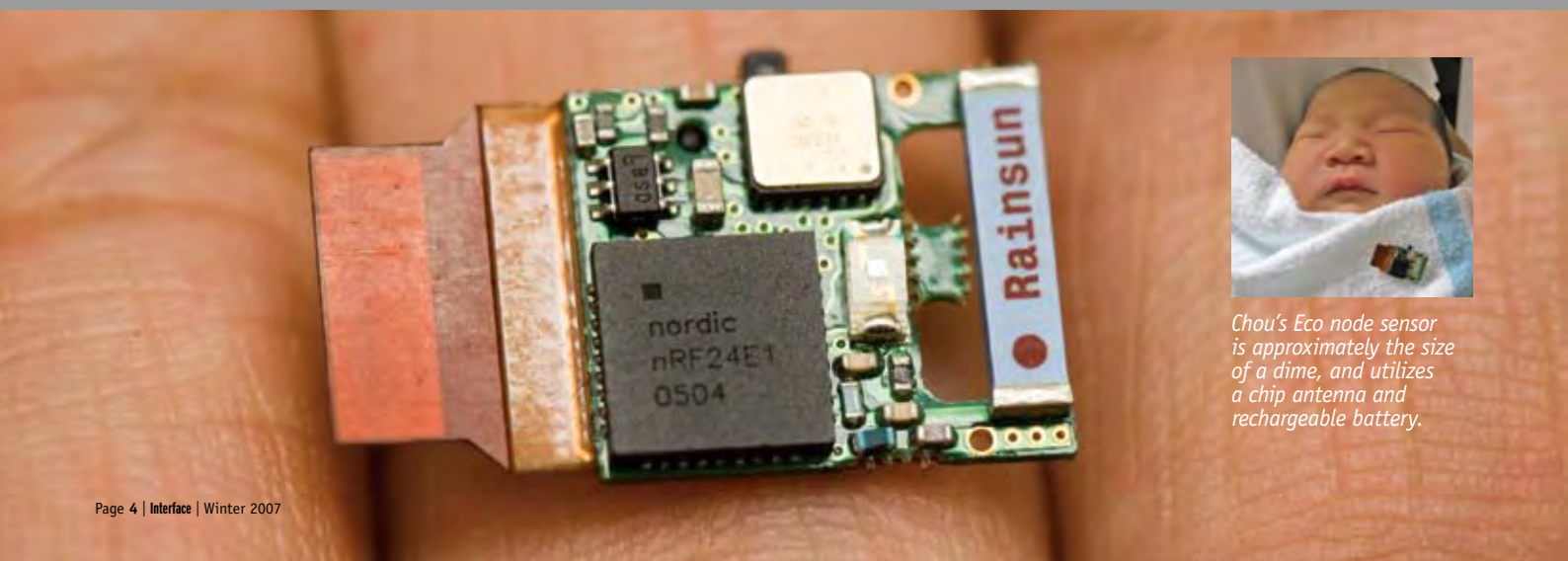
Research indicates that assisted exercise helps pre-term infants grow and doctors needed a way to monitor babies' motion. Miniature accelerometers showed promising results, but their wires rendered them cumbersome and inconvenient.

Chou is developing a tiny, wireless, MEMs-based sensor that consists of minute Eco (rhymes with pico) nodes that measure three-axial acceleration of the legs and arms, and measure the resistance value as voltage. Now in its third iteration, the sensor utilizes a chip antenna and rechargeable battery. It also has an expansion interface that allows it to be connected to external sensors.

Making the prototype was not an easy task. Because the boards are so small, soldering them is expensive, but the bigger challenge is maintaining their effectiveness. "It is quite difficult to make them so tiny without sacrificing performance," he says.

While awaiting further testing on infants, the sensors are proving useful in unexpected applications. Chou says they can be sewn into clothing worn by the elderly to detect falls, embedded into waterproof balls to measure the movement of sand under water, or even placed in cereal boxes to collect eating patterns for market researchers.

"What's so rewarding is that people in different fields are all excited and after seeing what we can do, they are asking us for more. It means we are onto something right."



Chou's Eco node sensor is approximately the size of a dime, and utilizes a chip antenna and rechargeable battery.

earthquakes that occurred in 2005, giving the system its first real test.

Like people, buildings and bridges can also suffer the effects of aging.

Bridge Requirements Differ

Feng also is monitoring the structural health of several local bridges, including three in Orange County and the Vincent Thomas Bridge in Long Beach. Recent studies indicate that 21 percent of highway bridges are rated structurally deficient. She hopes to avert tragedy – like last fall's highway overpass collapse in Canada – by continually measuring bridge vibration.

Standard electric sensors, originally fabricated for mechanical or aerospace systems, are not suitable for civil structures like bridges; they require cumbersome cabling, they're not durable, they are susceptible to electro-magnetic interference and they're easily damaged by weather conditions.

So Feng is designing fiber-optic sensors – one of which she patented in 1999 – that are smaller, lighter

(continued, page 6)

photo: LEDtronics, Inc.

Event Detective

Researchers Determine Odds of Unusual Incidents

Every visitor to the Calit2 Building at UC Irvine really counts.

Devices called "people-counters" have been installed near every door by Project ResCUE researchers, who use the small optical sensors to track the number of people entering and exiting the building – information that could prove crucial during an emergency evacuation.

Now, the sensors are aiding another Calit2 research project. By learning the building's normal traffic patterns, researchers have developed a way to determine the probability that an unexpected event could be occurring.

Padhraic Smyth, professor of computer science, postdoctoral scholar Alexander Ihler and graduate student Jon Hutchins tracked the people-counter data every 30 minutes over a period of three months. This allowed them to learn normal activity in the building's "living lab" environment. Then, for the next nine weeks, they compared real-time data from the people counters to the normal activity patterns they had learned previously. The majority of the events detected during that timeframe were later correlated to scheduled Calit2 Building events.

Determining Probability

The research application isn't confined to predicting the occurrence of an unusual event. Rather, it determines the probability of an atypical event occurring.

The software system isn't limited to data from cameras or people-counters, either. It can analyze any type of sensor that measures human activity, including highway sensors, ambient noise sensors and Web usage tracking.

"Once you know what 'normal' is... it's much easier to determine when something unusual is occurring."

The results have multiple real-world applications. The atypical event might indicate a large meeting in a building or it could signify something more ominous: a malicious attack on a Web server, a traffic accident on the freeway or a hostage situation.

Crisis Aid

Now that the software program is operational, the team is collaborating with Project ResCUE to develop an interface for the program based on Google Earth. The interface connects with the sensor database, enabling anomalous events to be identified on a map of the designated area. The end result will be an "information dashboard" that can be used by emergency operations centers for crisis assessment and response.

As part of this effort, researchers are working with data from the California Department of Transportation to analyze traffic patterns from 20,000 highway-embedded sensors in Los Angeles and Orange County.

The research team is also working with the fire department in Ontario, Calif. to implement the software as part of its emergency preparedness plan.

"It's just another information tool," says Hutchins. "Once you know what 'normal' is in a given situation, it's much easier to determine when something unusual is occurring."

Small, lightweight fiber optic sensors created by Feng are a fraction of the size of traditional electric accelerometers.

and impervious to harsh conditions. The sensors utilize a novel sensing mechanism that enables accurate and reliable measurement of micro-vibration as well as strong motion. The sensors and their fiber-optic cables are totally immune to electromagnetic interferences and lightning strikes.

The bridge research, funded by the California Department of Transportation, also utilizes strain sensors embedded into the concrete, accelerometers, displacement sensors and soil pressure sensors. Data recorders are installed on-site and – in the case of the bridge closest to the university – data are relayed to UCI by point-to-point antennae, and to the Internet, all in real time. The other bridges are too far from UCI to allow such connections, so the research team is working to create wireless relay options.

Recent studies indicate that 21 percent of highway bridges are rated structurally deficient.

Trial in the Living Lab

Before installing them in the field, Feng tests her sensors in the Calit2 Building's "living laboratory" environment. "We're constantly testing our new sensors in the building to compare them with traditional sensors," she says.

Feng envisions one day in the not-too-distant future, sensors will be

In the Calit2 recorder room, Soyoz connects IP converters that allow all data to be transmitted to the Internet.

installed in all critical infrastructures. Not only can they help prevent disaster, they can be useful in post-disaster scenarios like closing damaged bridges and overpasses instantly, and rerouting traffic. They're cost efficient as well, eliminating the need for licensed structural engineers to physically inspect infrastructure for damage after earthquakes.

Before that vision can become reality, Feng says, much work remains. "With both the hardware and software, we still have a lot of research to do."

To view the structural monitoring of the Calit2 building go to: *http://mfeng.calit2.uci.edu/Maria_Feng/Research_Activities/health_monitoring/waveform2_1.html*

Clever Sensors

Making Buildings Smarter

Another potentially life-saving gadget has been added to the assortment of products and projects that make up the Calit2@UCI "living lab" concept. Chris Davison, ResponSphere technology manager, installed multi-function sensor motes throughout the Irvine building as part of the project's ongoing effort to improve crisis communication and response.

"...we have more instrumentation in our coffee room than (is in) most cities."

"The Calit2 Building is certainly one of the most intelligent of the smart buildings," Davison comments. "Ellis Stanley (City of Los Angeles emergency manager and Project ResCUE Community Advisory Board president) likes to say that we have more instrumentation in our coffee room than (is in) most cities."

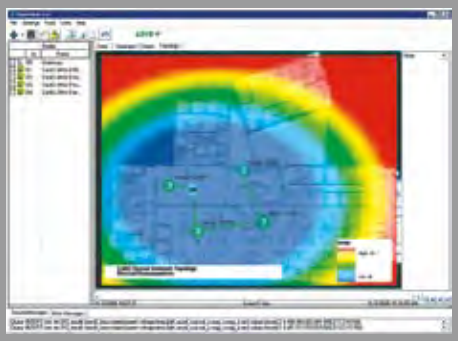
The motes contain temperature, humidity, acoustic and light sensors, accelerometers, magnetometers and an alert system that activates whenever any of the sensors reaches a pre-determined level.

The data collected by the motes stream in real time to a ZigBee network, a high-level communication protocol that uses small, low-power digital radios based on the IEEE 802.15.4 standard for wireless personal area networks. Sensor information is updated approximately every three seconds to a database that is part of the CAMAS-VM test bed framework and is available to anyone with network access.

"Anyone can obtain up-to-the-second sensor information about the Calit2 Building from anywhere in the world by querying the CAMAS database," Davison says.

He recently adapted the motes – which were originally battery powered – so that they can be plugged into electrical outlets for charging.

The motes are another effort by the ResponSphere team to quickly recognize changes in building conditions that could indicate emergency situations. Changes in temperature and light sensors could



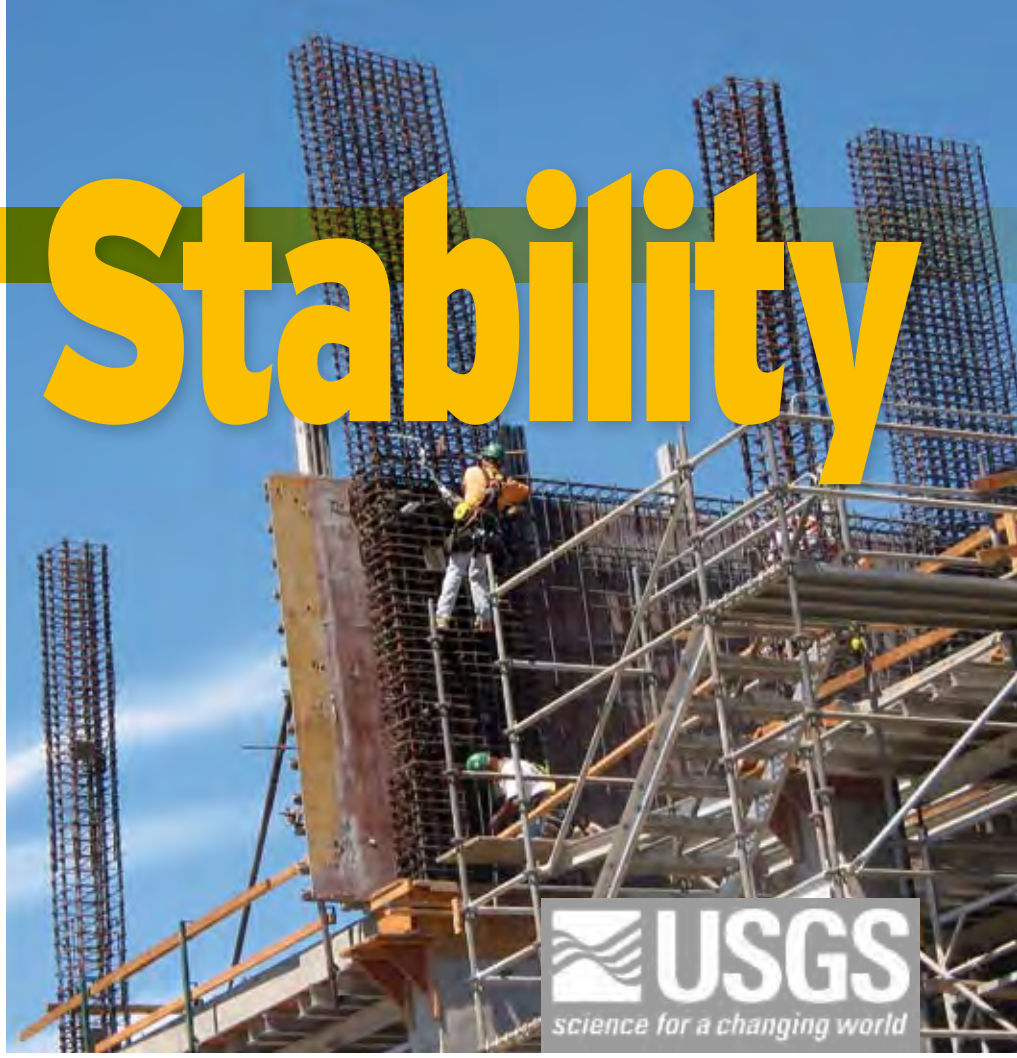
Screen shot of temperature data from the Calit2 Building's fourth floor. The real-time data are available to anyone with ZigBee network access.

be indications of explosion or fire; because the sensors are localized, responders would know exactly where to take action. The acoustic sensors measure ambient sound levels, where a drastic change could signify a problem. The accelerometers measure building sway on the x and y axes, while the magnetometer reads magnetic levels in the building.

"These motes stream real-time sensor data, so they can be utilized as a first indication of trouble in the building," says Davison.

A Sense of Stability

Partnership Built on Common Strengths



When UCI Engineering Professor Maria Feng suggested to Erdal Safak of the U.S. Geological Survey that he collaborate in her structural health monitoring research, it was the seismic researcher's version of an offer he couldn't refuse. Together they decided where to place motion sensors on the four-story Calit2 building and in the surrounding bedrock – the world's first system installed during construction to measure building and ground motion at the same time.

by Fran Tardiff

"Ultimately, the public will benefit in safer, more structurally healthy buildings."

In conjunction with the National Earthquake Hazards Reduction Program, the USGS's National Strong-Motion Project (NSMP) installs and operates a variety of ground- and structure-monitoring networks. The UCI collaboration made the Calit2 site one of more than 700 NSMP monitoring stations in 32 states and the Caribbean. They're all part of the USGS effort to reduce seismic hazards and improve public safety by collecting data on damaging earthquakes from both ground and structures.

Calit2 handled the installation of its 43 sensors, including 12 planted deep underground, at a cost of about $200,000. Through Mehmet Celebi, manager of structural monitoring for the USGS Earthquake Hazards Team in Menlo Park, Calif., the USGS supplied the sensors, as well as four data recorders located in the building. Owned by the USGS and placed at strategic spots on each floor and in the ground around the building, the sensors have been capturing data on the health of concrete beams, shear walls and columns, in addition to soil-structure interaction.

Vibrations: Normal or Damaging?

Unlike the lightweight fiber-optic sensors Feng uses in her bridge

monitoring research (see page 2), these are conventional spring mass accelerometers encased in metal boxes about a foot square and well suited to this particular function.

"The building is vibrating all the time from traffic, minor ground motion and other stresses," says Feng. "With this system, we no longer have to wonder about hidden damage from a quake or the normal aging process."

The system monitors real-time activity and provides a quantitative analysis of the changing characteristics of the structure. And the data can be remotely accessed on the Internet. Traditional qualitative examination is done by a licensed structural engineer who must visually inspect and diagnose the structure's health.

Understanding Structural Performance

Feng and Safak worked together on the Calit2 project for three years before he left the USGS to take a position as professor of earthquake engineering at Bogazici University in Istanbul, Turkey. "By recording vibrations during large and small earthquakes, the USGS gets data on the seismic response of the building," says Safak. "This is the main reason to monitor structures. Such data allow us to understand the behavior of structures during earthquakes, improve seismic design codes and design better buildings in the future. These are all important research goals for the USGS's earthquake hazards reduction program."

Although the USGS has been conducting structural monitoring research since the 1970s, adds Celebi, "The agency continues to advance its monitoring goals through collaborative projects using other sources of funding from federal agencies, local governments and educational institutions like Calit2."

Nationwide Sensor Network

In addition, in 1997, Congress requested the agency to "assess the status, needs and associated costs of seismic monitoring in the United States" and it authorized development of a real-time, seismic hazard warning system, which became the precursor of the Advanced National Seismic System.

Currently being developed and implemented, the ANSS is designed as a technologically sophisticated, nationwide network of more than 7,000 earthquake sensor systems established in hazard-prone areas. And, says Safak, the Calit2 station could one day come under the ANSS umbrella.

The system recorded two modest California earthquakes in 2005.

According to the USGS, the modernized system will provide almost continuous, real-time earthquake information for emergency personnel, give engineers information about building and site responses to strong shaking, and provide scientists with high-quality data to help understand earthquakes, as well as the structure and dynamics of the earth.

Meanwhile, the Calit2 system is ever vigilant. It has recorded two modest California earthquakes in June and September of 2005, in San Bernardino and San Clemente respectively. Both registered 4.9 on the Richter scale. Some soil vibration was detected, but the distant quakes didn't shake the building significantly.

"The building is in pretty good shape," says Feng, who emphasizes the importance of continuing this landmark collaboration with the USGS. "It's a natural affiliation and we hope that in the future we can implement this technology quickly and get it to those who can use the information it provides. Ultimately, the public will benefit in safer, more structurally healthy buildings."

In a pioneering partnership, 43 seismic sensors were provided by the USGS and installed by Calit2 while the building was under construction.

Picture Perfect Projection

Unique Technology Offers Seamless View

Medical and scientific researchers had a dilemma. Because most computer screens offer only about one million pixels, they couldn't view large digital picture files without scrolling up and down. They couldn't work on multiple documents without wasting time switching between screens.

by Anna Lynn Spitzer

Enormous data sets compounded the predicament. Researchers had to zoom in and out to locate specific data, while simultaneously attempting to view the whole picture.

The HIPerWall, in the Calit2 Visualization Lab at UC Irvine, resolves some of those issues. It utilizes 50 panels with a total resolution of 200 million pixels, providing a clear, grid-based look at massive data sets. But the seams around each panel break up the image, making the wall less effective in certain applications, such as virtual reality or simulations.

Fully Automated

What's a researcher to do when s/he needs a realistic, high-resolution, seamless display?

The quandary isn't confined to researchers. The military requires realistic simulators for training personnel. Architects want to visualize their work in high-resolution before breaking ground for a building. And entertainment companies want to build virtual environments in theme parks and hotels. All require lifelike, high-resolution visualization options.

Aditi Majumder, UCI assistant professor of computer science systems, had an idea.

She constructed a multi-projector display in the Calit2 Viz Lab that utilizes camera-based calibration techniques and custom algorithms to automatically align images and eliminate color variations.

Her display utilizes nine projectors, each of which connects wirelessly to a computer and a digital camera with computer interface.

The display is completely automated. Instead of an individual adjusting each projector to assure proper alignment, the camera and computer work together to automatically adjust the nine images. The camera "sees" the display and then defines the misalignment and color mismatch mathematically. A sophisticated algorithm is used to apply a digital compensation method that modifies the image going to each projector.

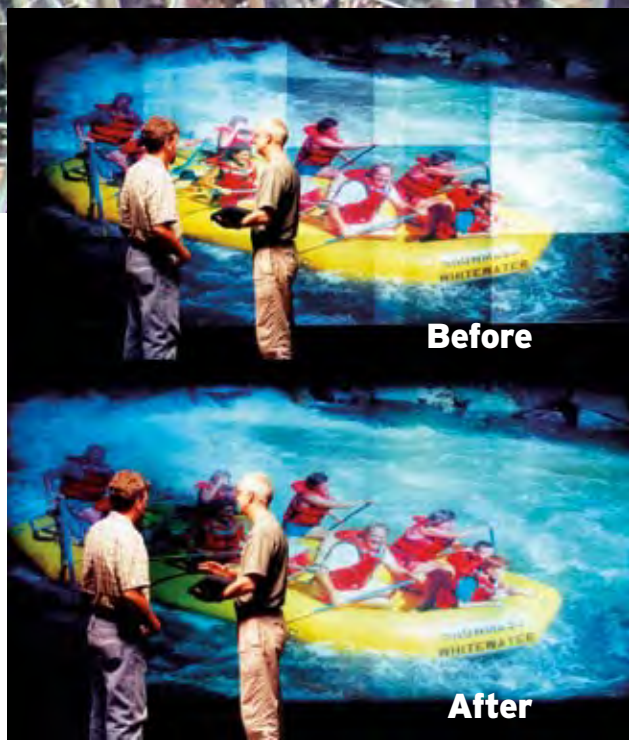
"The camera sees the display and communicates with the computer, which communicates with the projector, and the projector displays the correct image," Majumder explains.

The result is a 3,000 x 2,000-pixel, perfectly aligned, seamless image.

It is also color calibrated, without "hot spots," fading and color variations inherent in most

"The user can place any number of projectors in any configuration... (and obtain) a truly seamless and high-resolution display."

Majumder points out seams and color variations produced by multiple projectors in an uncorrected image.



multi-projector displays.

Majumder's innovative color-correction solution is based on human perception.

The optimization method factors in the human eye's inability to distinguish whether something is truly uniform. The result: a perceptually seamless display that does not sacrifice brightness or contrast.

"We are probably the only place in the U.S. right now that makes use of human perception to calibrate color," says Majumder.

The whole process –geometric and color correction – takes approximately one hour, and can be applied to any image, including video.

Next-Generation Systems

Now, Majumder and her students are developing a "plug-and-play" version. The completely scalable, reconfigurable, and easily assembled-and-operated product can be used by anyone, anywhere. Assembly requires no technical expertise.

A computer chip, a wireless connection and a small, inexpensive digital camera are embedded in each projector, so each can "see" its own output as well as some of what the projectors next to it are emitting. Thus, each projector is self-sufficient and can manage its part of the display independently.

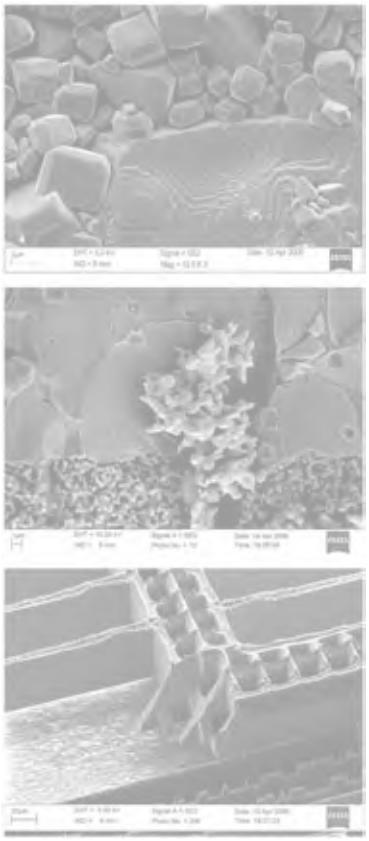
"We designed a completely distributed architecture where each projector can manage its own pixels, creating a self-calibrating display that operates without user intervention," she says. "The user can place any number of projectors in any configuration. The distributed algorithms take over, yielding a truly seamless and high-resolution display," Majumder says.

The technology also makes these displays portable for the first time. They can be easily deployed in temporary situations such as emergency incident sites or war zones. "Multiples of these inexpensive one-pound portable units are much easier to move than one 300-pound projector and can provide 10 to 100 times the resolution," she says.

She adds that these plug-and-play units also have the potential to change the very definition of collaboration. "Imagine every person carrying his own projector and when they meet, they put them together to create one large, high-resolution display.

"Our goal is to create the super high-resolution display of the future: inexpensive, flexible, perceptually seamless and easily assembled by anyone in minutes."

Update: Zeiss Center of Excellence



One year ago, Carl Zeiss SMT entered into an agreement with Calit2@UCI to bring state-of-the-art scanning electron microscopy to the Irvine building. The Zeiss Center of Excellence, valued at $2.5 million, is available to industry and faculty on a recharge basis. The high-level microscopy is particularly useful to the Southern California aerospace, biomedical, semiconductor and energy systems industries.

New Materials Characterization Director Joins Team

An electron microscopist and materials physicist with more than 20 years of experience joined the Irvine division of Calit2 in September as director of the institute's materials characterization facilities.

Jian-Guo Zheng will direct activity for the Nanomaterials Characterization and Fabrication Facility (NCF2), a newly integrated university-wide user facility managed by Calit2 that includes the Zeiss Center of Excellence. Other labs under the NCF2 umbrella include the clean rooms and Polymer Characterization lab in the Calit2 Building, and the Materials Characterization Facility, located in UCI's Engineering Tower.

Prior to joining Calit2, Zheng was manager of the Electron Probe Instrumentation Center at Northwestern University, and a research assistant professor in Northwestern's Department of Materials Science and Engineering. His research focus is advanced electron microscopy, materials physics, soft materials and biomaterials.

The three cutting-edge scanning electron microscopes in the Zeiss Center of Excellence are available for use by faculty and industry.

Zeiss Center Welcomes New Applications Specialist

Ed Basgall, a microscopist with more than 30 years of experience, is the lab's new chief technician. He was most recently at Penn State, where he worked in electron beam lithography systems and nanofabrication for 10 years.

Basgall has a doctorate in nutritional sciences, and extensive experience in biological specimen preparation for microscopy as well as materials science. He is responsible

for all lab equipment and its usage.

There have been a couple of other staff changes in the Zeiss Center of Excellence as well. Carol Levers is the new sales manager for the Southwest region, while Joe Hovendon, who formerly managed sales, is now strategic marketing manager for Zeiss' U.S. operations.

Lab Faculty Oversight Committee Created

Calit2@UCI convened a new faculty committee to oversee and provide academic research perspective for the institute's Nanofabrication Characterization and Fabrication Facilities (NCF2).

The committee, chaired by Daniel Mumm, assistant professor of chemical engineering and materials science, will meet regularly to ensure that the facilities represent the interests of researchers from a wide range of departments, from physical and biological sciences to engineering and health sciences. Committee members will determine and monitor all lab policies and procedures to ensure that the labs are easily accessible to diverse users and that they contain the necessary equipment to support UCI's research mission.

The committee is also establishing guidelines for recharge rates, staffing needs and responsibilities, user education and certification standards, and access criteria for lab users.

"The goal is to make sure the facilities remain fully equipped and accessible to campus users – faculty, students and post-doctoral researchers – as well as off-campus academic and industry users," said Mumm.

UCI committee members include Bill Tang, professor of biomedical engineering; Adam Summers, assistant professor of ecology and evolutionary biology; Peter Burke, assistant professor of electrical engineering and computer science; and Phil Collins, assistant professor of physics and astronomy.

HoWARD Lends a Hand

Robotic Device Aids in Stroke Recovery

Unite a robotic engineer, a stroke neurologist, an occupational therapist and a computer scientist in the pursuit of better stroke rehabilitation, and what do you get?

by Anna Lynn Spitzer

"When you move your hand, your brain is listening."

Meet HoWARD. A computerized robot that helps improve stroke patients' hand mobility, HoWARD – Hand-Wrist Assisting Robotic Device – is the brainchild of Calit2 academic affiliate Steven Cramer, M.D., associate professor of neurology; former UCI postdoctoral fellow Craig Takahashi, who's currently assistant professor of engineering at Santa Ana College; Lucy Der-Yechiaian, UCI Medical Center occupational therapist; and Vu Le, College of Medicine neuro-imaging programmer.

Cramer, who researches the brain's repair mechanisms after stroke or spinal cord injury, had investigated many approaches to rehabilitation. Everything pointed to the benefit of repetition in rebuilding motor skills.

"It's clear that an important part of making things move better is practice. It's like learning to play the piano," he says.

Four Expert Viewpoints

Soon after arriving at UCI in 2002, Cramer met Takahashi, who expressed interest in his idea of a rehabilitative hand robot. Cramer then recruited Der-Yechiaian and Le for their respective proficiencies.

"We wanted to build a solid program from an engineering point of view, that improved the hand in a way that only a stroke neurologist would know, in a manner relevant to how an OT helps people, where the robot interfaces with a virtual reality-type program," Cramer says.

Having a four-person team was advantageous, Takahashi says. "This research is multidisciplinary in nature, so it required collaboration. Each team member brought his/her expertise to the table."

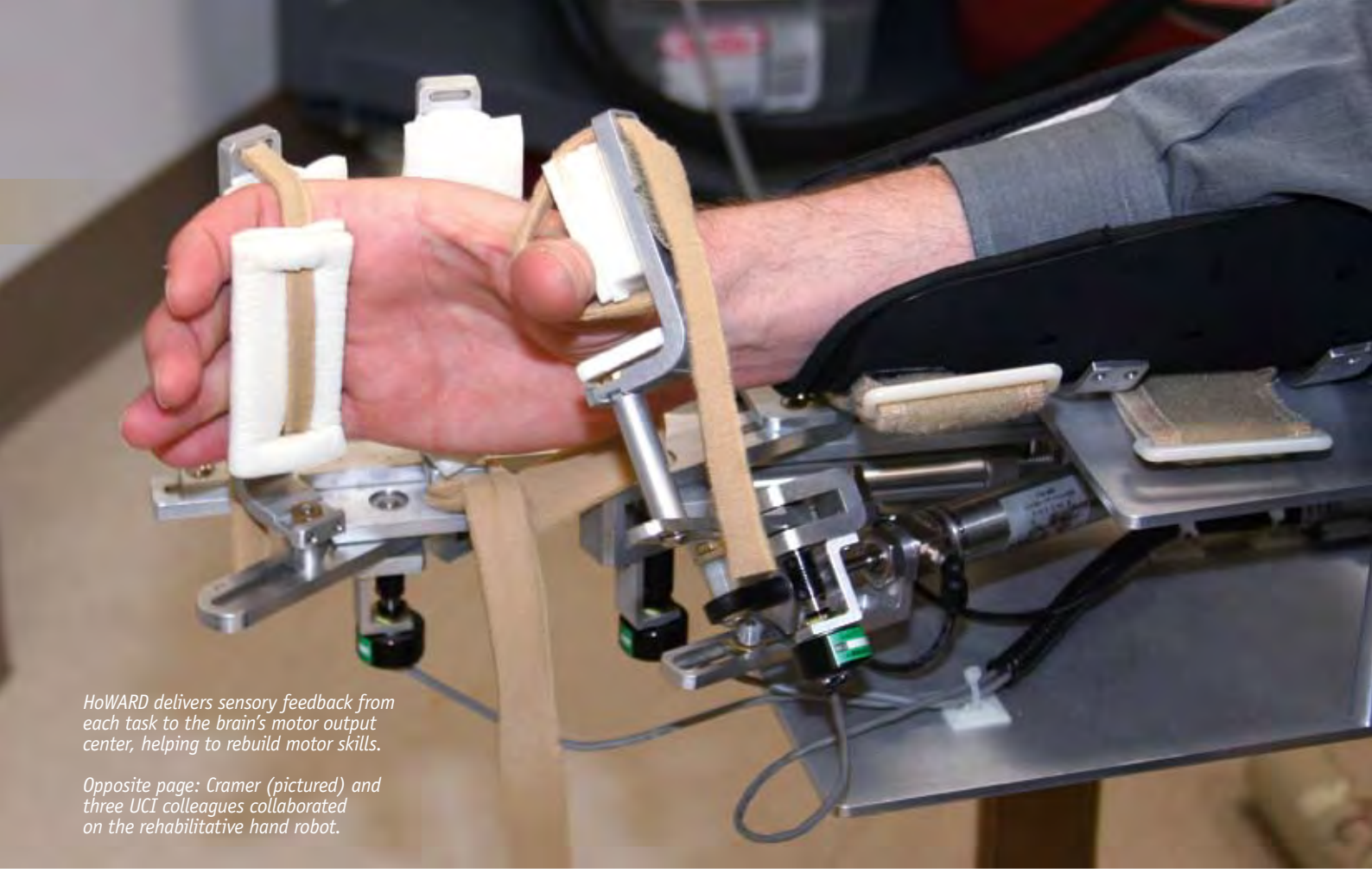
Fun, Games and Hard Work

Takahashi relied on neurological input from Cramer and therapy guidance from Der-Yechiaian as he built the prototype, then Le wrote the software interface and computer games.

"The human hand is quite intricate and no two people move their hands the same way," he explains. "The challenge was designing a device that could accommodate many different hands… within a limited budget."

The result: a pneumatically actuated, three-degrees-of-freedom (wrist, thumb and four fingers movement) device. Using interactive video games, it helps stroke patients relearn the grasping and releasing movements crucial for daily living tasks.

During therapy, with the right hand



HoWARD delivers sensory feedback from each task to the brain's motor output center, helping to rebuild motor skills.

Opposite page: Cramer (pictured) and three UCI colleagues collaborated on the rehabilitative hand robot.

strapped into HoWARD, the patient is instructed to repeatedly open or close the hand, and attempt other tasks shown on a computer screen. To keep it interesting, Le programmed several unique games and exercises. Patients are cued to grab an object as it travels by, or squeeze a lime or drop 'gems' into corresponding geometric shapes.

Patients must attempt each task alone, but after three seconds, HoWARD uses air-driven pistons to help.

"When you move your hand, your brain is listening," Cramer explains. "When HoWARD helps complete a task, that shapes the movement and delivers sensory feedback into the brain's motor output center.

"It's important that the patient initiates the movement," he adds. "Whatever s/he can't complete, HoWARD reminds the brain how it feels to go the rest of the way."

Currently, a therapist augments the treatment by using real objects in some exercises to encourage tactile stimulation. Cramer says the team is working to automate that task and integrate it into HoWARD's repertoire.

A Promising Future

Results from the first clinical trial were encouraging.

Thirteen stroke patients with similar baseline skills were divided into two groups; each received 20 hours of therapy over three weeks. Group A, in the first half of the sessions, attempted to complete the tasks without assistance; HoWARD helped out during the second half. Group B used HoWARD the entire time.

> **"It's clear that an important part of making things move better is practice."**

Motor skills in both groups increased steadily. Group B boasted significantly greater improvements than Group A, further confirming HoWARD's effectiveness.

And one month after therapy ended, all patients showed slight declines in their abilities, indicating the significance of continuity.

Cramer is pleased. "We weren't looking for numbers to jump off the scale," he says. "We wanted a functional tie-in – to demonstrate that if they can improve by 30 percent, maybe they can go shopping (by themselves)."

Mapping Brain Results

The study's tangible results were confirmed by changes in the sensorimotor cortex of the brain. Functional MRIs administered to the participants revealed an increase in cortical representation for the practiced tasks, while non-rehearsed tasks did not result in any brain changes.

Cramer has obtained an NIH grant for HoWARD's next clinical study, which he hopes to begin sometime this spring.

And one day, he would like to see HoWARD go wireless for tele-rehabilitation applications. "I think robotic therapy with intelligent communication in the home is the wave of the future," he says. "Instead of therapists treating one patient at a time, they could have a bank of monitors in front of them and treat 10 patients at a time. There's no reason that couldn't happen."

At the Intersection of

UCI dancers in "Ootoo," an Active Space telematic performance by John Crawford and Lisa Naugle.

Kids get it – because at the crux of the art and technology convergence is imagination. Could a cockroach drive a robot car? Can flying pigeons monitor air quality and then share their findings in a Blog? Can an artist dance with a computer?

by Lori Brandt

"Some of the greatest creativity and innovation emerge when you have thinking from multiple disciplines."

These are some of the ideas that have blossomed into research projects during the past few years, stewarded by UCI faculty and students exploring their talents in art, science and technology.

UC Irvine and Calit2 are aiming to expose this relatively new art form to a wider audience.

"Not everyone gets new media art. Not everyone likes it. But more and more people can see the practical applications," says Don Beall, former chairman and CEO of Rockwell International Corp., and a Calit2 Advisory Board member. "Some of the greatest creativity and innovation emerge when you have thinking from multiple disciplines, and that goes for art and science, as well as any other mix."

The UCI campus, with exceptional physical, intellectual and creative resources, has become fertile ground for projects that push the envelope of artistic expression and technological capabilities.

Exploring New Techniques

Calit2 is one of the few academic research institutes whose mandate encompasses the convergence of art and technology. In its fully networked arts studio and lab, researchers explore techniques in virtual reality, spatialized audio, robotics, motion capture, streaming media, game networks and new human-computer interfaces.

But even before Calit2 opened its doors, UCI's Claire Trevor School of the Arts had established one of the world's leading new media arts exhibition spaces, promoting new forms of art using the latest digital technologies. Artists from around the world submit proposals to exhibit at UCI's Beall Center

Art & Technology

for Art and Technology. One of the exhibitions that premiered last year, "OP_ERA," went on to earn international recognition with a first prize award at an electronic arts festival in Mexico and was purchased for the permanent collection at ZKM in Germany, one of the few new media centers in the world.

CTSA is also home to one of UCI's most popular minors – digital arts – with 500 students from across campus admitted, and many more on the waiting list.

Furthering Artistic Expression

"With its emphasis on digital arts, UCI has cultivated a group of faculty that is extremely comfortable in both artistic and technological domains – this is highly unusual, unique even," comments Albert Yee, Calit2 Irvine division director.

"One important aspect of supporting the growing relationship between the arts and sciences is that artists challenge technologists to create novel technological solutions for artistic expressions," continues Yee.

Lisa Naugle, associate professor of dance and Calit2@UCI Division Council member and media arts lab manager, agrees: "Artists aren't solely using existing technologies to create or influence their art. We are involved in developing new technologies. Calit2's structure allows us to bring together different kinds of arts and technologies into a single work, enabling us to produce art work that is a collaboration of two or more artists."

In April, Naugle and arts assistant professor John Crawford will stage a telematic dance/media performance in the Calit2 media arts lab, using Crawford's "Active Space" interactive environment. UCI dancers will perform in sync with dancers at New York University through the Calit2 high-bandwidth network.

"Throughout history, new art forms are often seen as controversial," says Eleanore Stewart, director of the Beall Center. "But these projects are the building blocks, the germinal ideas of the art of the future."

What's your favorite Beall Center exhibit?

Since its founding in 2000, the Donald R. and Joan F. Beall Center for Art and Technology has illuminated people's perceptions of art. The center was established with a gift from Rockwell Corp. in honor of its retiring chairman and his wife. The Beall Center's regular patrons keep returning, and invariably they all have a favorite show.

"I thought the one featuring mobile sculptures to produce music, light and images was marvelous (LEMUR)."
- Albert Yee, Calit2@UCI director

"I liked the virtual music box a lot (OP_ERA). Of course, I also enjoyed the alternative games show (ALT+CTRL)."
- Don Beall, new media art supporter

"My favorite was 'Through the Eye of the Wolf.' It was a wonderful demonstration of the potential of computer games, plus people really enjoyed 'howling with the wolves'."
- Eleanore Stewart, Beall Center director

"My favorite show at the Beall Center was 'Five (5)'. The exhibit was provocative without being inaccessible, and was the first show that made my friends with no previous new media arts exposure sit up and say 'wow, I get it.' "
- Cat Moore, UCI literary journalism major

To view these and other Beall Center exhibits, visit: *http://beallcenter.uci.edu/virtual/virtualvideo.php*.

FUNDING NOTES

by Stuart Ross

Calit2 is interested in and can assist with funding proposals for many kinds of sensor and sensor-network-related projects. Available funding opportunities – along with their deadlines – include:

Nanoscience and Nanotechnology in Biology and Medicine
National Institutes of Health
June 20, 2007
-Solicitation PAR-07-270
Nanosensors could be of vital importance in the early detection of disease, detection of low levels of toxic exposure, and in assessing the structure and function of biomolecules. This solicitation is for the development of new sensors, not the application of existing ones.

Research Opportunities in Aeronautics
National Aeronautics & Space Administration
July 6, 2007
- Solicitation NNH06ZEA001N
NASA needs advanced work in many areas of sensor research related to aeronautics and space exploration. Sensor research is mentioned often in this broad solicitation, specifically on sensors for high temperatures, flow distortion, pressure, strain and operator physiology, among other variables. Ceramic and cermet sensors, sensor ruggedization, sensor failure detection, sensor data fusion and data interpretation software are also topics of interest. Depending on the specific subprogram, most awards are for $100,000 to $500,000.

Biophotonics
National Science Foundation
Sept. 15, 2007
- Solicitation PD-07-7236
NSF is seeking research projects on the use of photonics devices for biomedical sensing – biosensors capable of detecting and discriminating among large classes of biomolecules, using technologies such as lens microarrays, quantum dots, plasmon surface resonance, and novel waveguiding structures.

Control Systems Program
National Science Foundation
Oct. 1, 2007
- Solicitation PD 05-1632
This program is concerned with the integration of sensors into complex civil or mechanical systems that include sensing, actuation and computation.

Sensor Innovation and Systems
National Science Foundation
Oct. 1, 2007
- Solicitation PD 05-1639
This program within NSF's division on civil, mechanical and manufacturing innovation will fund research on advanced sensors for engineering solutions and strategic decision-making for safety, security and reliability. Important themes include adaptive system performance through dynamic response control, innovative actuating capabilities, and micro and wireless networks.

Strategic Technologies
Defense Advanced Research Projects Agency
Dec. 31, 2008
- Solicitation BAA 07-01
This Broad Agency Announcement covers many topic areas, and sensor technology figures prominently among them. For example, proposals are sought for space and near-space sensors, including large-aperture and large-array systems. Research projects on sensors for material identification, sensors for urban use, underwater sensors, and low-power sensors would also be appropriate candidates. Submission of a one-page summary is the first step; if the summary is of interest, a full proposal will be invited.

Sensors and Electron Devices
Army Research Laboratory and Office
Ongoing until Sept. 30, 2011
- Solicitation W911NF-07-R-0001
One of the topic areas in the Army's Broad Agency Announcement is "Sensors and Electron Devices." Emphasis is placed on such topics as distributed and multi-modal sensing, nanosensors and disposable sensor/communication packages. Research on electrical, magnetic and optical problems relevant to sensing is also of interest. Submission of a preliminary 'white paper' is encouraged before submission of a full proposal.

Information Technology Laboratory & Construction Engineering
Research Laboratory Engineer Research and Development Center U.S. Army Corps of Engineers
Proposals accepted at any time
This is a Broad Agency Announcement with specific areas of interest. Some areas include artificial neural networks for processing and interpretation of sensory data; graphical user interfaces for controlling sensors or displaying sensor output; smart sensors that process and interpret their data; infrared, optical and acoustic sensors; advanced charge-coupled device-based sensory systems; high-shock, high-frequency sensors; intelligent building control systems; sensors for water quality and flow; pressure and chemical sensors; and digital sensing methods. Also of interest are sensors for monitoring structural response, for monitoring dams or locks, for measuring sediment transport, for measuring roadbed or bridge response, for measuring stream velocity gradients, or for measuring pollutants.
Please contact stuross@calit2.uci.edu about any of these opportunities.

Expert's Guide

Second Life

Bill Tomlinson is assistant professor of informatics in the Donald Bren School of Information and Computer Sciences. His research interests include computer graphics, human-computer interaction, autonomous agents, interactive animation, computational social relationships and multi-device graphics.

What is Second Life?

Second Life (SL) is an online virtual environment – a networked, animated computational world inhabited by thousands of characters, each of which is directed by someone in real life (RL). You can download the software and make one of these characters for free at *http://www.secondlife.com*. SL was created in 2003 by Linden Lab, a company led by Philip Rosedale (known as Philip Linden in SL).

How many people currently participate?

SL has had a total of more than 2 million "residents" who have logged on at some point. Right now there are 16,289 people logged on. You can see these and other statistics at the URL above. English is the primary language in SL, but residents may be from anywhere in the world that has computers with fast Internet access.

Is any special equipment required?

Aside from a reasonably fast computer (Windows or Mac) and cable or DSL net access, no special equipment is required.

Are there similar sites on the Internet? How does Second Life differ?

There are a number of other sites/games that have existed that share characteristics with SL. "World of Warcraft" is a virtual world with more than 7.5 million players. A virtual world called "There" was popular a few years ago, but it has largely been eclipsed by SL. "The Sims Online" was also similar in a lot of ways. There are a number of other virtual worlds that are very popular in Asia (particularly South Korea).

What sets SL apart is that it is designed to let residents create their own content. You can build your own house, buy furniture from other residents, design your own clothes, etc. Linden Lab makes their money by charging for membership (you can't create objects that remain over time without being a member) and for "land use fees" if you want to own virtual real estate. SL has a thriving economy of people making things and selling things using a currency called Linden Dollars (L$). L$ may be converted to and from US$, with the current exchange rate floating around L$250 = US$1. So there are some people who make neat things in SL, sell them to other residents and cash out for a profit. There are a number of very successful virtual real estate brokers in SL as well.

How are these communities changing online advertising?

Just as there is advertising in RL, there can be ads and other corporate presences in SL. American Apparel has a store in SL, Wells Fargo has an island, and Suzanne Vega did a concert there. The American Cancer Society raised more than $40,000 (US) in its Second Life Relay for Life in July 2006.

What attracts people to these online environments?

People participate in SL for a variety of reasons. Some like the sense of community that exists among different groups inworld. Others like building things. Still others see it as a possible way to make money that's better than their real job.

Could Second Life potentially change the way people interact with each other in the real world?

It already has. Last summer when I was traveling quite a bit, my research group had our group meetings in SL. Sometimes my mom (who lives in Santa Cruz) and I wander around together in SL. There is fluidity between RL relationships and SL relationships.

What is the future of Second Life and other online communities?

It's hard to say. Clearly there will be a continuation in improvement of graphical quality and performance of these communities. However, I expect that the most striking changes will come in the way these virtual worlds develop socially. It will be interesting to see how these virtual worlds mesh with the real world as they grow in popularity. There are now hundreds of millions of people in the world with email addresses, and the World Wide Web is no longer just the domain of computer geeks, academics and military personnel; how would the real world change if virtual worlds became similarly popular?

Playing Games is Serious Business

According to the Brookings Institution, computer gaming had an $18 billion dollar impact on the U.S. economy in 2005 and is estimated to grow $15 billion more by 2010, while industry employment is expected to leap nearly 75 percent in the next couple of years. UCI students interested in the gaming profession demonstrated their first-quarter efforts in a hands-on demonstration in the Calit2 Building in December. Students worked in teams to develop, design and program a game that could be played on various digital technologies such as cell phones, PDAs and laptops.

Korean Technology Pioneer Visits

Dr. Myung Oh, former Korean minister of science and technology, who is known as the "pioneer of Korea's telecommunications revolution," visited Calit2@UCI last fall to investigate opportunities for collaboration. Oh, who was chosen by Korea's leading business newspaper as a top-10 public officer in recognition of his contributions to the growth of the nation's information and telecommunications sector, is currently president of Konkuk University in Seoul. The university specializes in science and technology education.

Grad Fellow Joins World's Elite

Daejeon, South Korea was host in October to the 2006 Young Investigators Forum in Culture Technology. Man Lok (Simon) Yau, a Calit2-Emulex doctoral candidate in computer sciences, was one of only 12 students from around the world chosen to attend the prestigious technology conference. Participants at the forum discussed the future of culture technology and how it is helping to shape modern environments. Yau, who works on the Calit2 EcoRaft Project with Assistant Professor Bill Tomlinson, said that the interactive nature of the workshop presented a valuable opportunity for him to introduce his research on an international level and get feedback from other students and professors.

Discovering Technology Partnerships

A UC Discovery Grant opportunity award enabled Calit2@UCI to showcase the future in networking and communications systems last fall. The program led by Rui de Figueiredo, professor of electrical and computer engineering, drew a large crowd to discuss the benefits and challenges inherent in developing network-centric communications systems. Presenters from Boeing, Sprint Nextel and the Los Angeles Joint Regional Intelligence Center shared their perspectives on next-generation technologies, data collection and information sharing, and interoperability. UCI research teams presented their networking and communications-related work in breakout sessions with hopes of generating potential industry collaborations via UC Discovery funding opportunities.

Living and Learning

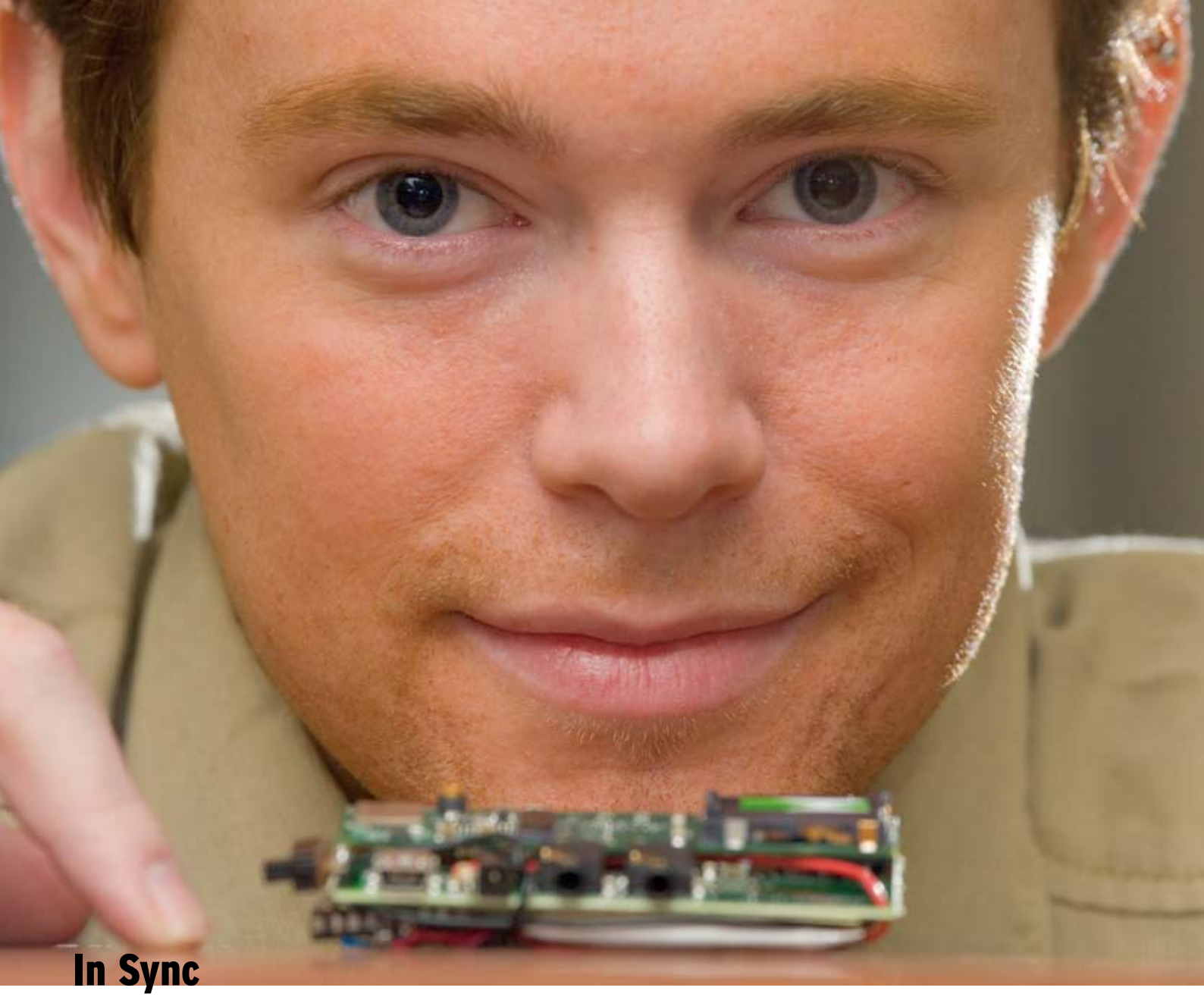
"A fascinating and thought-provoking experience" was one attendee's description of his participation in the Osher Lifelong Learning Institute's Calit2 program "Living in the Future is Not So Distant After All." The OLLI program, managed by UCI Extension, offers courses to seniors who have a passion for learning and keeping up with the latest research. In November, Southern California chapter members attended a series of classes and lab demonstrations showcasing Calit2 research in the areas of the environment, entertainment, medicine and robotics. Members, whose average age is mid-70s, engaged faculty and graduate student presenters with thoughtful questions and historic perspectives. OLLI plans to partner with Calit2 again next fall.

Gadgets and Gizmos

Gizmo, a remote-controlled toy truck tricked out by Calit2@UCSD researchers, was among new emergency response technology prototypes demonstrated at the first Project ResCUE Community Advisory Board meeting last fall in Irvine. Each Gizmo has a Calit2 CalMesh ad-hoc network board equipped with both wireless local area network (WLAN) and global positioning system (GPS) cards. A single truck can serve as an autonomous platform on wheels to deploy a number of technologies. Javier Rodriguez Molina is the lead Gizmo gadgeteer, as well as a UCSD engineering graduate student.

State-of-the-Art Games

UCI faculty representing nine departments and five schools converged in October at Calit2 to discuss computer game research. Each of the participants has an interest in some element of the academic study of gaming. The workshop, led by professors Bill Tomlinson and Bonnie Nardi, was designed to help unify the diverse research efforts. The group was joined by a few colleagues from UCSD and USC, and a handful of researchers from several Southern California gaming companies. The interdisciplinary team identified the current state of the art in computer game research and suggested ways for Calit2 to combine future research efforts.



In Sync

Feel like going for a run? Want your music to keep up? Calit2-Emulex graduate fellow Greg Elliott is giving new meaning to "being in sync." The Arts Computation Engineering student is developing a tiny, wearable computer that detects your pace and chooses songs from your personal music library to match it. If you speed up a bit, the song speeds up imperceptibly, conforming to your gait. If your speed changes significantly, the device automatically chooses a new song that's more appropriate.

The personal soundtrack, no bigger than an iPod Nano, runs on a lithium ion battery. It also contains Bluetooth technology; Elliott's next goal is to add a multiplayer game to the device.

The California Institute for Telecommunications and Information Technology is a two-campus multidisciplinary research institute. In collaboration with UCSD, Calit2@UCI integrates academic research with industry experience to seek innovative IT approaches that will benefit society and ignite economic development.

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