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California Institute for Telecommunications and Information Technology

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University of California, Irvine

Smart Move

interface-2-face

A Smart Approach

It used to seem as if we had inexhaustible amounts of water and energy. But now we're seeing that these resources are limited and we have to manage them in a more thoughtful way to enable economic growth that can bring billions of people out of poverty.

Calit2 researchers are exploring possible solutions to these economic and environmental challenges.

One hope lies, paradoxically, in exponential growth – in the underlying information infrastructure that increasingly ties our physical world together. This leads to a vision of deploying a new generation of "smart" infrastructure.

Imagine putting networked sensors and actuators inside aqueducts, levees, agricultural fields and buildings. These sensors send information in real time back through a computing system that creates simulations of our climate, hydrology, energy distribution and transportation systems. This "faster-than-real-time" simulation feeds back into the networked actuators, which then adjust water and energy flows, making our civil infrastructure and agriculture vastly more efficient.

These dreams will soon become reality. California is about to spend hundreds of billions of dollars to rebuild its physical infrastructure and Gov. Schwarzenegger has vowed that the state will build the "smartest" infrastructure in the world.

While the challenges we face are daunting, there's a perfect storm of innovation developing in the intersection of IT, telecom, nanotech, biotech and energy. This gives the more than 1000 researchers at Calit2 hope of a "greener" and economically thriving planet, enabled by extending information systems throughout the physical world.

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QualITy of Life

IT-Based Infrastructures Power Smart Solutions

by Anna Lynn Spitzer

ACT ONE, SCENE ONE: *Cars idle bumper-to-bumper on a Southern California freeway, stretching as far as the eye can see. Tailpipes emit noxious fumes while drivers do their own slow burn.*

ACT ONE, SCENE TWO: *Relaxed commuter disembarks from train at station, walks to front row of parking lot and swipes "smart card" against reader on windshield of Toyota RAV4 electric vehicle. Car unlocks automatically and engine activates. Commuter unplugs car and drives to nearby workplace.*

(continued, page 2)

APEP's Lorin Humphries manages the ZEV•NET fleet, which will more than double in size next year.

It's not a pipe dream anymore. The fleet of electric vehicles known as ZEV•NET (Zero Emission Vehicle• Network Enabled Transport) resides at the Irvine Transportation Center. ZEV•NET is one of several real-world solutions born at UC Irvine that integrates information technology in the quest for a cleaner, greener world.

From transportation to power generation to resource monitoring and modeling, IT-based infrastructures will play a vital role in improving our planet's environment.

Shared Use, Energy Efficiency

A collaboration among the California Air Resources Board, Toyota, and two UCI Calit2-affiliated research centers – the Advanced Power and Energy Program (APEP) and the Institute for Transportation Studies – led to the creation of ZEV•NET in 2002.

The battery-powered RAV4s provide zero-emission transportation. The only shared-use station car program in Southern California, the ZEV•NET fleet is comprised of 16 Toyotas that are contracted to four local companies and a UCI department. Plans are underway to more than double the program's size next year to 40 cars, and 16 additional companies have expressed interest in participating.

California is the world's 12th largest source of carbon dioxide, the heat-trapping gas that most scientists believe is a source of global warming

ZEV•NET is user-friendly. Employees commute by train to the Irvine station, drive the vehicles to their companies and share them during the day with co-workers who use them for local business. At day's end, commuters drive back to the train station, where, for now, they recharge the cars using power from the electric grid. Renovation of the station's parking structure is currently underway, and when completed, will include a

photovoltaic canopy that converts sunlight into electricity for vehicle charging. An onsite fuel cell will provide electricity during non-daylight hours.

Convenient, easy to use and good for the environment. And without IT – impossible.

Users reserve the cars with a Web-based program that triggers a wireless signal, letting a specific car "know" it has been reserved. Drivers access assigned cars with their "smart cards" and when the vehicles are returned, the system logs them in, rendering them available for the next user.

No human intervention is required.

Cars also are equipped with GPS. Usage information is conveyed wirelessly back to UCI, where researchers track the program's effectiveness.

Modeling the Future

APEP is also working with Toyota to evaluate a prototype plug-in gas/electric hybrid vehicle. The project is part of a $3 million research effort funded by

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Coloring the Future Green

ome to a top-ranked public university, more than 24 international company headquarters and a population that has quadrupled in the last quarter century, the City of Irvine is going to great lengths to "go green."

It was the first city in the U.S. to implement curbside recycling and recently added residential e-waste pickup. The first city in Orange County to adopt a "green building" ordinance, it was also the first in the world to ban the use of chlorofluorocarbons.

"Shouldn't we want to do those things that we have the tools to do and that make this a better world?"

Irvine recently launched a business/energy coalition to encourage local businesses to reduce energy consumption and is distributing 50,000 free compact fluorescent bulbs to residents for the same reason. A member of the National Coalition of Cities for Climate Protection, it uses compressed natural gas in many of its city cars.

"We have to challenge ourselves to look beyond what affects us immediately," said Irvine Mayor Beth Krom. "Shouldn't we want to do those things that we have the tools to do and that make this a better world?"

The city's Great Park, a 1,347-acre parcel under development in the heart of Orange County, is being designed and built with an eye toward sustainability.

"We want the Great Park to be a 'living laboratory' of innovative technology," Krom said.

Features will include habitat restoration, renewable energy generation, water quality management and sustainable transportation.

Water will be captured and cleaned as it flows through the park and recycled for irrigation.

Developers plan to install more than one megawatt of renewable energy generation on site. Park lighting will be powered by small photovoltaic cells attached to lamp posts that will produce energy from sunlight.

Additional ideas under consideration include a bio-diesel production center that will turn processed cooking oils into fuel for park shuttle buses; the availability of bicycles for in-park transportation; 10 solar dishes that will generate up to 25 kilowatts of electricity each; and an anaerobic digester that will generate heat and electricity by processing landscape trimmings and food waste.

In addition, developers plan to construct the park's sidewalks and roads from more than 3.5 million tons of concrete and steel recycled from the Marine base that formerly occupied the site. In lieu of curbs, developers want to plant ditches with grasses and willows to catch water run-off.

In both city operations and in the new Great Park, Krom hopes Irvine will continue to implement innovative environmental programs.

In both city operations and in the new Great Park, Krom hopes Irvine will continue to implement innovative environmental programs.

"We are collectively working on a daily basis to have a greener, more sustainable future for the city and for other communities in Orange County," she said.

Photo: Paul Kennedy

Samuelsen believes information technology will become the "lifeblood" of future energy and transportation systems.

the state to determine how air quality and electricity demand will be affected if the vehicles are widely used.

Researchers will create computer models that simulate the environment at mid-21st century. "We will look down the road and simulate a California urban air basin to assess the impact on air quality as the population of plug-in hybrids increases," says Scott Samuelsen, director of APEP and its flagship, the National Fuel Cell Research Center (NFCRC). "Everyone assumes air quality will improve, but that needs to be established quantitatively."

Samuelsen foresees a day when monitoring agencies and utility companies will utilize similar computer models not only to predict problems, but also to trigger responsive action.

"If everyone driving electric cars plugs into the grid to recharge after work, it could be disastrous," he says.

A "smart plug" built into the vehicles will transmit two-way information along with electricity. Utility companies will have the ability to monitor at what time and how often consumers plug in their vehicles and can institute conservation tactics.

A graduated pricing structure, for example.

"In the future, when you plug in, a chip will identify you to the grid," predicts Samuelsen. "You might get a message saying, 'you can charge your car now but it is going to cost you more because it's peak hours. If you want to pay less, leave it plugged in and we'll recharge it when there is less demand on the grid, and it will still be ready by the time you need it.'"

Depending on grid conditions or air quality, agencies could even curtail access to electricity or disable gasoline engines if necessary – all from their computer keyboards.

And in the direst conditions, when demand outpaces supply, an IT-enabled system will siphon off energy from vehicles plugged into the grid and direct it to more crucial needs.

That could allow utilities to shave peak power requirements and avoid building new generation plants, and transmission and distribution lines.

"Utilities are intrigued with this concept because not only can they potentially use that battery storage (in the hybrid cars) during peak power demand, but it would help them level out daily grid demand," says Samuelsen. "It's a win-win situation and it will all be IT-driven."

Distributing Power Generation

The California power grid routes electricity from power plants to substations, providing access for more than 30 million consumers.

From transportation to power generation to resource monitoring and modeling, IT-based infrastructures will play a vital role in improving our planet's environment

Approximately 80 percent of that electricity is generated by burning fossil fuels, a process that emits carbon dioxide and other greenhouse gases.

In fact, California is the world's 12th largest source of carbon dioxide, the heat-trapping gas that most scientists believe is a source of global warming. In an attempt to reduce emissions, Gov. Arnold Schwarzenegger

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Catalyst for Change

Bill Tomlinson and his Social Code research group use information technology in a slightly different way to confront environmental challenges.

The researchers are not creating cleaner fuels or more energy-efficient systems – instead, they are using IT as a catalyst to educate the public and enact social change.

Three ongoing projects in Tomlinson's lab in the Calit2 Building employ the latest technology in an attempt to change society's habits.

GreenScanner *(www.greenscanner.com)*, an online database of consumer opinion, gives shoppers access to information about the environmental friendliness of various products.

The project is based on a publicly available database of more than 900,000 products, each with its own UPC code. Tomlinson, assistant professor of informatics, hopes the Web site will become a forum where shoppers can read comments on whether products are environmentally friendly before they buy.

He also expects that in the not-too-distant future, when mobile devices have faster data access, the application can be downloaded to cell phones and PDAs, giving consumers information instantly as they shop.

EcoRaft simplifies restoration ecology for children.

Graduate student Joel Ross conducts a GreenScanner user study.

EcoRaft is a multi-device computer game that teaches children the basics of restoration ecology. The game has been demonstrated at venues around Southern California, including Orange County's Discovery Science Center, and work is underway on the next-generation version. Improvements may include incorporating smaller handheld devices and infrastructure changes.

The researchers also hope to expand the project's scope. "We would like to build a series of exhibits for different locations; each would incorporate several species indigenous to that area," Tomlinson says.

Making the future better through technology, he adds, causes previous technology to become obsolete quickly and "this generates a lot of waste." **E-waste tracking**, a collaboration with informatics professor Bonnie Nardi, traces the movement of discarded computer components.

AnyDATA tracking devices help locate discarded computer components.

Using AnyDATA tracking devices embedded in the components and visualizing the data on Google Maps, Tomlinson hopes, will compel consumers to change their habits.

"Letting people know more about where their waste went and what happened to it might cause them to reconsider some of their choices with regard to purchasing or consumption," he says.

The paddle used to recharge ZEV•NET cars may someday transmit two-way information along with electricity.

signed AB 32 in September 2006. The bill requires a 25 percent reduction – to 1990 levels – in carbon dioxide pollution in the state by 2020. By 2050, emissions must be reduced another 80 percent.

"It's a win-win situation and it will all be IT-driven."

One approach to meeting these requirements is a concept known as distributed generation, in which electricity is produced at the site of its use. Power is generated by means of small-scale technologies, including fuel cells, microturbines and photovoltaic cells. These technologies utilize renewable energy sources as well as conventional fuels like natural gas.

The systems capture "waste" heat from the fuel cell or combustion-based devices and use it in heating or cooling applications. This increases overall efficiency, displaces the use of additional fuel or electricity for those needs, and ultimately reduces the amount of greenhouse gases and other pollutants.

UCI's NFCRC is the poster child for distributed generation. A 5-kilowatt fuel cell sits behind the building, supplying enough electricity to meet the peak demands of an average home. Photovoltaic cells, which convert sunlight to energy, are placed on the roof, enhancing reliability of the building. "If the grid does down, we can rely on our fuel cell to produce electricity," Samuelsen says.

Developing Virtual Utilities

Information technology is crucial to these systems. Generators can be monitored and operated over the Internet, creating a virtual utility. "The word 'virtual' is key; IT is making it possible for someone sitting in an office to monitor and control these distributed resources," Samuelsen says. "If the grid goes down, a person sitting in a different city can switch the power entirely to distributed generators."

In Orange County, only a few businesses have distributed generation systems, but the trend is "growing like wildfire," he says.

Across the state, the Franchise Tax Board, Pasadena City College, Santa Barbara County Jail, L.A.

Department of Water and Power, and U.S. Postal Service stations, among others, utilize the systems.

A small number of homes – perhaps 1 percent – have photovoltaic panels on their roofs to produce electricity. To increase homeowner participation, Samuelsen's team is working to develop a better residential system and hopes to test a combined photovoltaic/fuel cell power generator within the next few years.

Information is Power

To educate companies about the benefits of distributed generation and its environmental impact, APEP has teamed up with the California Energy Commission (CEC) to monitor electricity consumption around the state.

Sophisticated equipment collects energy-consumption data up to several times a minute from six sectors – hotels, hospitals and other health-care facilities, jails and prisons, colleges and universities, commercial office buildings and food service businesses, including grocery stores and warehouses. The data, which include total electric power, and power demands for air conditioning, refrigeration and heating, will be collected for 12 consecutive months and streamed back to UCI, enabling researchers to get a complete, year-long overview of energy usage in each sector.

"The evolution of electric power generation and transportation will depend on IT."

When the project ends in February 2009, APEP will compile the data and deliver a detailed database to the CEC. The resulting broad-based analysis will indicate the feasibility of installing on-site distributed generation systems in each business sector.

"This is something that has never been done before," says Rich Hack, APEP senior research engineer. "There have been spot checks done or a detailed analysis for a month or so, but no one's ever tried to do it for an entire year."

The second phase of the APEP/CEC collaboration will determine how distributed generation systems impact surrounding air quality. Although the state and the Southern California basin will benefit in general, emissions at locations adjacent to the generator may be higher than they were before.

"That's what we're hoping to find out," says Hack.

It's another mission that will be enabled by the IT workhorse. Streaming high-resolution data from 100 locations statewide to UCI, manipulating the information into a database, developing analysis tools – all are virtually impossible without information technologies.

"The evolution of electric power generation and transportation will depend on IT," sums up Samuelsen. From the customer to the utilities to the environmental monitoring agencies, IT is "the lifeblood that will enable these systems."

Photos: Jeff Kubina

Spanhake created the wireless mobile device that can turn cell-phone users into pollution monitors.

Squirrel Sense

Calit2 San Diego Device Samples Air Pollution

By Doug Ramsey

For all the clamor about "green" technologies to clean up the air we breathe, the Environmental Protection Agency has deployed surprisingly few pollution sensors – even in major metropolitan areas where pollution can be a problem.

Since 1990, for example, the population of San Diego has risen by 1.8 million people, yet there has been only one new, official pollution monitor installed in the county. That brought the total number of dirty-air monitoring systems to a scant handful, plus a few more operated by Mexican authorities on the other side of the border in Baja California.

"Every person with a cell phone could become a pollution monitor, taking readings 24/7."

Now a researcher in Calit2's UC San Diego division has devised a simple but revolutionary response to the lack of raw pollution data. Engineer-turned-artist Shannon Spanhake wants to turn cell phone users into pollution monitors. As Spanhake sees it, any citizen with a wireless phone and a tiny Bluetooth-enabled device called a Squirrel would be able to sample air pollutants effortlessly and send the data via cell phone to a public Internet database for the entire world to see.

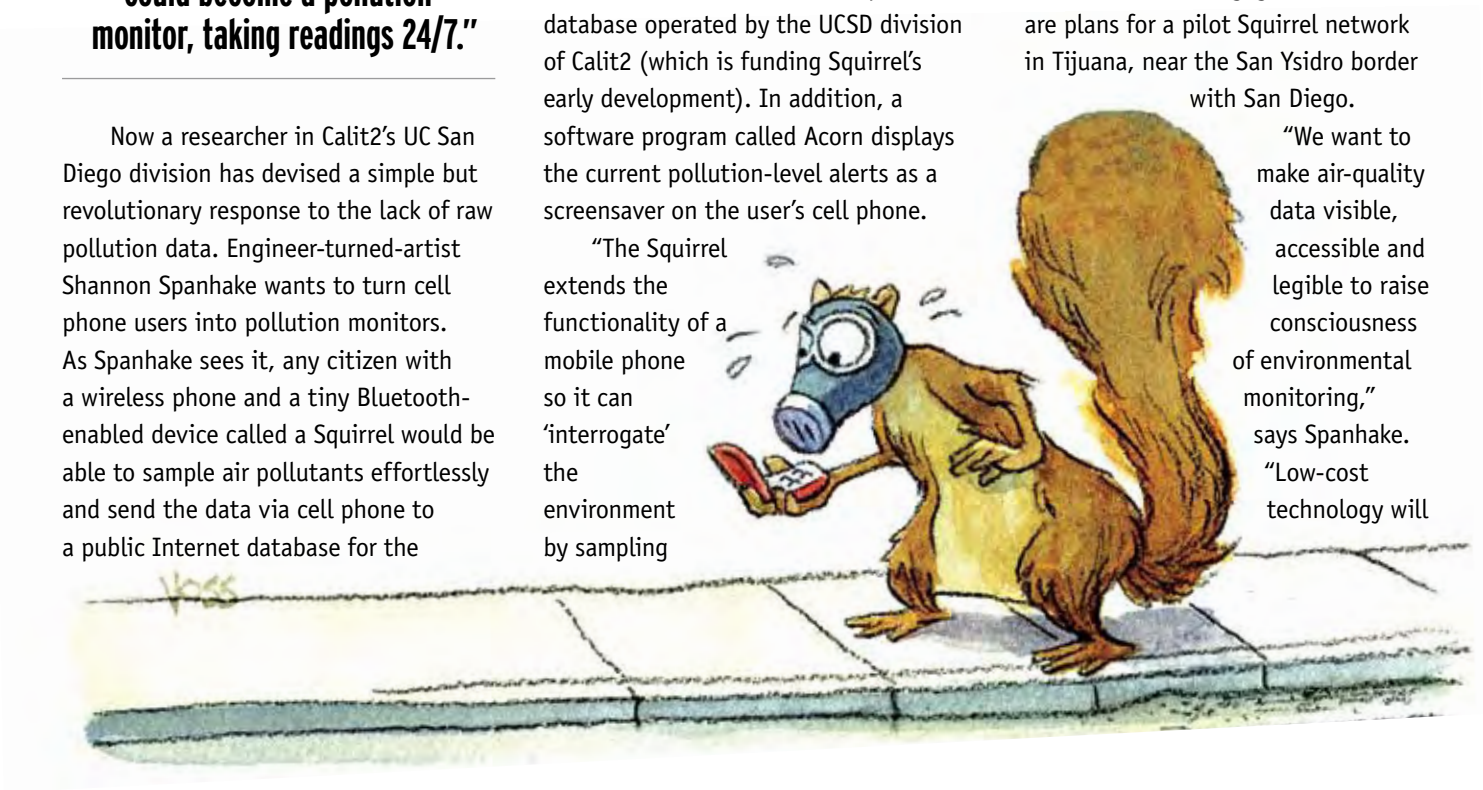
"The price of wireless and sensor technology is making it feasible that every person with a cell phone could become a pollution monitor, taking readings 24/7 and feeding the results wirelessly to a database," says Spanhake. "That would give us a lot more concrete data on which to make informed decisions about how to fight pollution at the level of the individual, the region and the country."

A Powerful Tool

The Squirrel, a battery-powered mobile device that samples pollutants with an on-chip sensor, fits in the palm of your hand and can be clasped to a belt or purse. The current prototype measures carbon monoxide and nitrogen dioxide and/or ozone, but eventually the device will be able to sample other indicators of air quality, as well as the surrounding area's temperature, barometric pressure and humidity.

What happens next could make the Squirrel a powerful tool in the fight against pollution. Using its short-range Bluetooth wireless transmitter, the device connects to the user's cell phone, which periodically transmits the environmental data to the public database operated by the UCSD division of Calit2 (which is funding Squirrel's early development). In addition, a software program called Acorn displays the current pollution-level alerts as a screensaver on the user's cell phone.

"The Squirrel extends the functionality of a mobile phone so it can 'interrogate' the environment by sampling key pollutants," says Spanhake, who did her undergraduate degree in electrical engineering and received an MFA in visual arts from UC San Diego.



Ground-Level Measurements

Spanhake initially worked with Calit2's Circuits Laboratory to build and refine an early prototype of the device, and her own lab's current focus is on driving down the size and cost of the Bluetooth-enabled sensor unit.

The personal pollution device also measures pollution where people live and breathe – at ground level – whereas most existing sensors are located on top of buildings.

Spanhake showed an early version of the device at the 6th annual Gadgetfest last December, and since then she has demonstrated it at a number of meetings, including this year's Emerging Technology Conference (ETech) in La Jolla, where it was a big hit.

"A reporter from the BBC did an audio interview, CNET News dropped by, and a reporter from Reuters asked lots of questions," recalls Spanhake.

Social Responsibility

As conceived by Spanhake, the Squirrel is a bold exercise in social responsibility and cross-border engagement. There are plans for a pilot Squirrel network in Tijuana, near the San Ysidro border with San Diego.

"We want to make air-quality data visible, accessible and legible to raise consciousness of environmental monitoring," says Spanhake. "Low-cost technology will also make it available and scalable to the technological, environmental and cultural needs of individuals, communities and cities."

But Spanhake knows that it will take more than great technology and a noble cause to achieve widespread adoption of the Squirrel. She is talking with experts in technology commercialization as well as venture capitalists about potential ways to make the system available to a large number of people. The Calit2 researcher doesn't rule out creating a for-profit startup company that would sell the Squirrel as the "green" accessory that no environmentally-savvy consumer should be without.

From Focaccia to Fuel

Re-Engineering Yeast to Improve Ethanol Production

For thousands of years, a common yeast strain has been used to make bread, beer and wine. Now, unique research underway in the Calit2 Building at UC Irvine aims to transform it into something more: an efficient producer of ethanol to help meet the nation's increasing thirst for "green" energy.

by Anna Lynn Spitzer

Unigue research underway at Calit2 sows the seeds for new fuel options

Scientists in the Computational Biology Research Lab (CBRL) are collaborating with researchers in the schools of information and computer sciences, engineering and medicine, and researchers at CODA Genomics, an Orange County synthetic biology company. They are working on a new way to make the clean, environmentally safe fuel.

As the United States searches for environmentally friendly ways to reduce its dependence on foreign oil, ethanol has emerged as a possible option. It is high octane, clean burning and renewable.

Problem is, it's difficult to produce and in the past, has derived primarily from corn. UCI and CODA Genomics researchers are collaborating to tweak the genetic structure of a yeast strain called *Saccharomyces* so that it can produce ethanol more efficiently and from additional sources of biomass – switchgrass, hemp, wood and other natural materials.

Modifying Genetics

Saccharomyces produces ethanol as a byproduct when it ferments glucose found in plant materials. But it does not contain the necessary enzymes to process other sugars in biomass, such as xylose and arabinose.

Researchers are using CODA Genomics' patented gene-protein-production algorithms to modify the yeast's genetic structure. The re-engineered version will produce enzymes that allow it to digest other sugars as easily as glucose, maximizing its ability to produce ethanol.

Current production methods make use of approximately 20 percent of the sugars in corn 'stover' – the dried stalks and leaves that are left after harvesting. Plus, the most widely used methods employ fossil fuels to break down the stover and separate the sugars before processing.

Scientists believe this new version of *Saccharomyces* will use 80-90 percent

From left: Researchers Sandmeyer, Baldi, Salmon and Hatfield are confident of the project's success. Not pictured: Nancy Da Silva.

of the sugars in a much wider variety of biomass to produce ethanol. And it will do so unaided, avoiding expensive, carbon-emitting procedures.

"While there currently are yeast strains that can make ethanol from biomass, the existing process is very expensive and inefficient. We're trying to build a better yeast strain – one that can produce more ethanol from the same amount of biomass by breaking it down naturally," says G. Wesley Hatfield, professor emeritus, principal investigator on the project and a CODA Genomics co-founder.

The $1.67 million research collaboration began Sept. 1 and is funded by CODA and a UC Discovery Grant that provides matching funds for innovative industry-university research partnerships.

Multidisciplinary Endeavor

CODA, which spun off in 2005 from UCI research, sells kits that manufacture synthetic genes. Its biggest customers have been pharmaceutical and biomedical companies that use them to develop and test new drugs.

The company's patented technology uses computer algorithms to design the genes to self-assemble easily and generate protein in large amounts, allowing them to be re-engineered to meet the needs of different organisms. When applied to *Saccharomyces,* the technology modifies the yeast so it can manufacture additional enzymes that can break down more sugars.

Even when the yeast produces the necessary enzymes, inefficiencies in its metabolic pathways can slow the process. Pierre Baldi, director of UCI's Institute for Genomics and Bioinformatics (IGB) and a co-principal investigator, is computationally "optimizing" key enzymes to increase their efficiency. With computer algorithms, he is engineering compatibility of these key enzymes with various co-factors – the small molecules that help the enzymes work. Baldi is also Chancellor's Professor in the Donald Bren School of Information and Computer Sciences.

"Given the current energy crisis and global warming concerns, we are excited about the potential outcome," he says.

Also involved in the multidisciplinary project are IGB faculty members Suzanne Sandmeyer, from the School of Medicine's Department of Biological Chemistry, and Nancy Da Silva, from the engineering school's Department of Chemical Engineering and Materials Science.

CBRL scientists perform the computation, gene design and gene assembly of the yeast proteins using CODA's technology. Sandmeyer and Da Silva insert the optimized genes into the yeast genome, ensuring the enzymes' stability and ability to function. They also make certain that fermentation conditions are optimal to maximize ethanol production.

Future Energy

The biofuels team brims with confidence about the project's potential. "We already have made important advances towards the key issues," says project scientist Kirsty Salmon. "We hope to have even more enabling results in the coming months."

Robert Molinari, founding CEO, CODA Genomics, is pleased that the company's expertise might lead to the development of more efficient energy producing methods.

"The CODA technology is already showing commercial success in therapeutic protein markets," he says. "Now we are going to apply the unique approach to a large national problem."

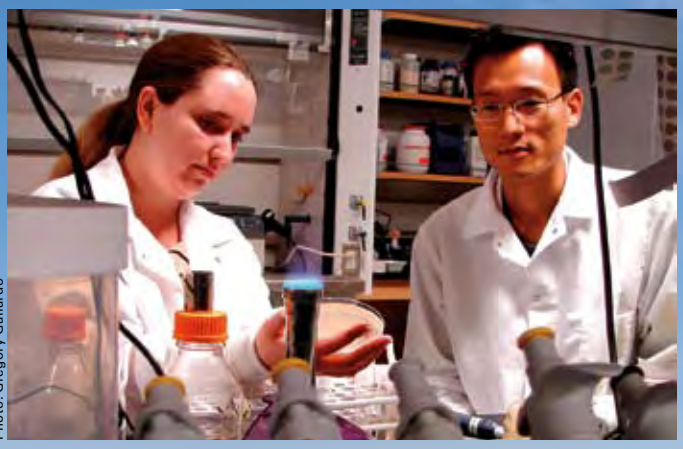


Photo: Gregory Gallardo

Kimberly Aeling (left), a postdoctoral research fellow, helps graduate student Jin Wook Choi screen recombinant clones.

Budding Beauty

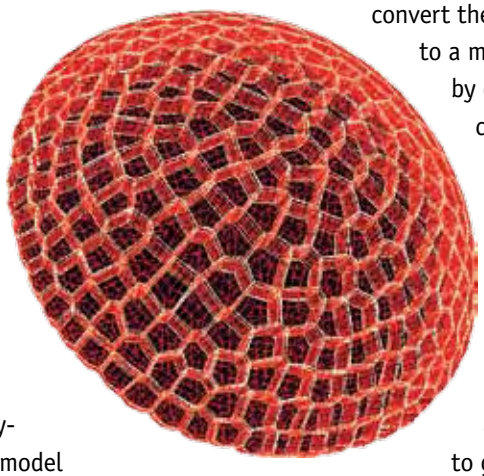
Computable Plant Increases Scientific Understanding

It isn't particularly fashionable or trendy, but it's a model nevertheless. A computer model, that is. *Arabidopsis,* a small flowering plant in the mustard family, is the diva of a computer modeling experiment that will help scientists better understand how and why plants grow the way they do. This insight can lead to advances in global sustainability, ecology, agriculture and energy.

by Anna Lynn Spitzer

"Modeling allows biologists to make hypotheses about complicated systems containing many cells and interacting molecules."

Principal investigator Eric Mjolsness, a UC Irvine Calit2-affiliated computer scientist, and co-PI Elliott Meyerowitz, a Caltech plant biologist, are collaborating on the "Computable Plant," a $5 million NSF Frontiers in Biological Research grant that combines computing, microscopy and molecular biology. They are developing a mathematically-based computer model of *Arabidopsis'* growth cycle, specifically its arrangement of leaves – known as phyllotaxis – and its shoot meristem, the sets of stem cells at the tip of each shoot, which ultimately provide the cells that make the stem, leaves and flowers.



Biology Meets Computing

Meyerowitz' team captures live images of the plant's leaf growth with a confocal laser scanning microscope.

Mjolsness and his UCI colleagues convert the biological processes to a mathematical format by designing a series of computer models to reflect the plant's cell growth, cell communication and molecular regulation. The models are visually brought to life on a computer, allowing the scientists to gain insight into the plant's growth process.

The team also designs algorithms to quantify those images. "Image analysis algorithms allow us to see where the growth is happening, where it is slow and where it is fast," Mjolsness says, adding that compared

to human analysis, a mathematical approach saves hundreds of hours.

Finally, Mjolsness and his collaborators compare the computer models with time-lapse-microscope movies of actual plant development to see if their theories check out.

"Modeling allows biologists to make hypotheses about complicated systems containing many cells and interacting molecules," says Mjolsness. "You can run mathematical models forward and see what would happen if your hypotheses were true. Then you can compare that to what you're actually observing."

Understanding Patterns

In particular, the collaborators are developing a model based on the movement of the growth hormone auxin, which influences how the plant's shoots, roots and leaves are patterned.

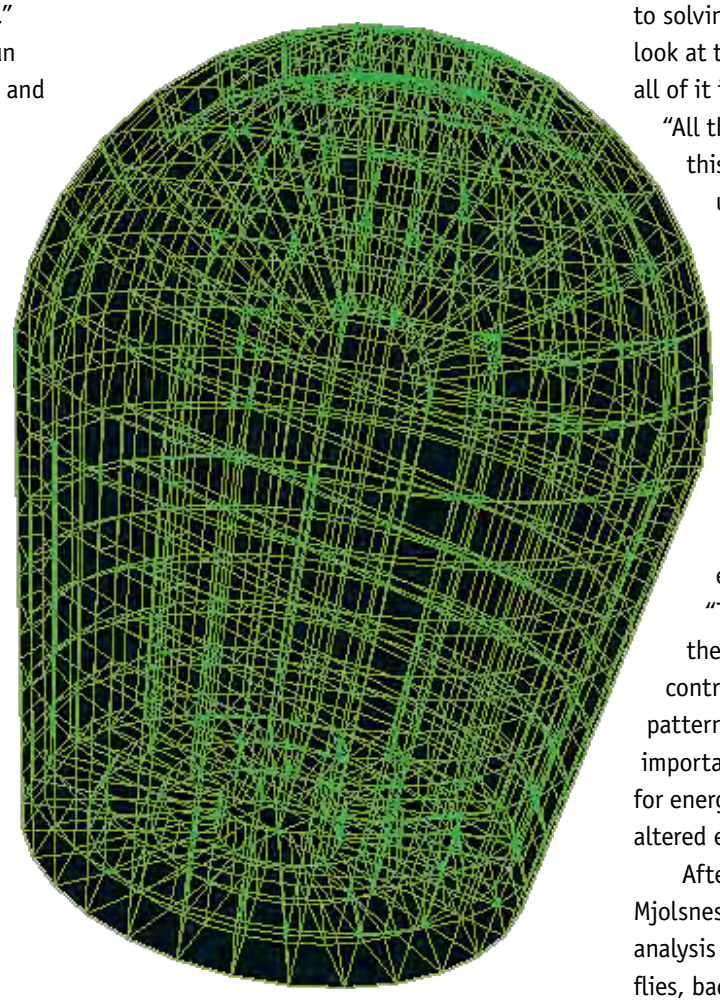
Because placement of the plant's organ may be influenced by localized concentrations of the hormone, it's important to understand how the auxin moves between cells.

New research suggests that auxin can manipulate its own movement by regulating which cell membranes contain the necessary proteins to direct it. If scientists can confirm this "autoregulated transport," it would offer a new look at the workings of cell communication in biological development.

Mjolsness says his group wants to understand in greater detail the plant forms and structures that are visible to the eye. Why do many plants have a spiral pattern of flowers, leaves and branches? Why do the flowers grow in specific locations on the plant?

"We can explain the morphology in terms of molecules, genes and proteins that we know. But if you change one of these components, everything about the morphology could change," he says. "We are trying to understand why."

Understanding spatial patterning in plants can set scientists on the path to solving universal problems



Global Benefit

The researchers have noticed that plant tissue makes room for new floral buds by moving the older primordia, which compete for auxin, out of the way. This helps to explain why new leaves at the shoot tip occur as far as possible from old ones.

Understanding spatial patterning in plants can set scientists on the path to solving universal problems. "If you look at the terrestrial biosphere, almost all of it is plant life," Mjolsness says. "All the questions that arise from this biosphere will benefit from an understanding of the way plants give rise to their adult form."

The associate professor of information and computer science was originally a physicist. He pursued research in computer science to help him solve complex physics problems computationally.

Now he's applying his expertise to the plant world. "The ability to reengineer the architecture of plants by controlling their basic spatial patterning mechanisms could be important in redesigning plants for energy, food or growth in altered environments," he says.

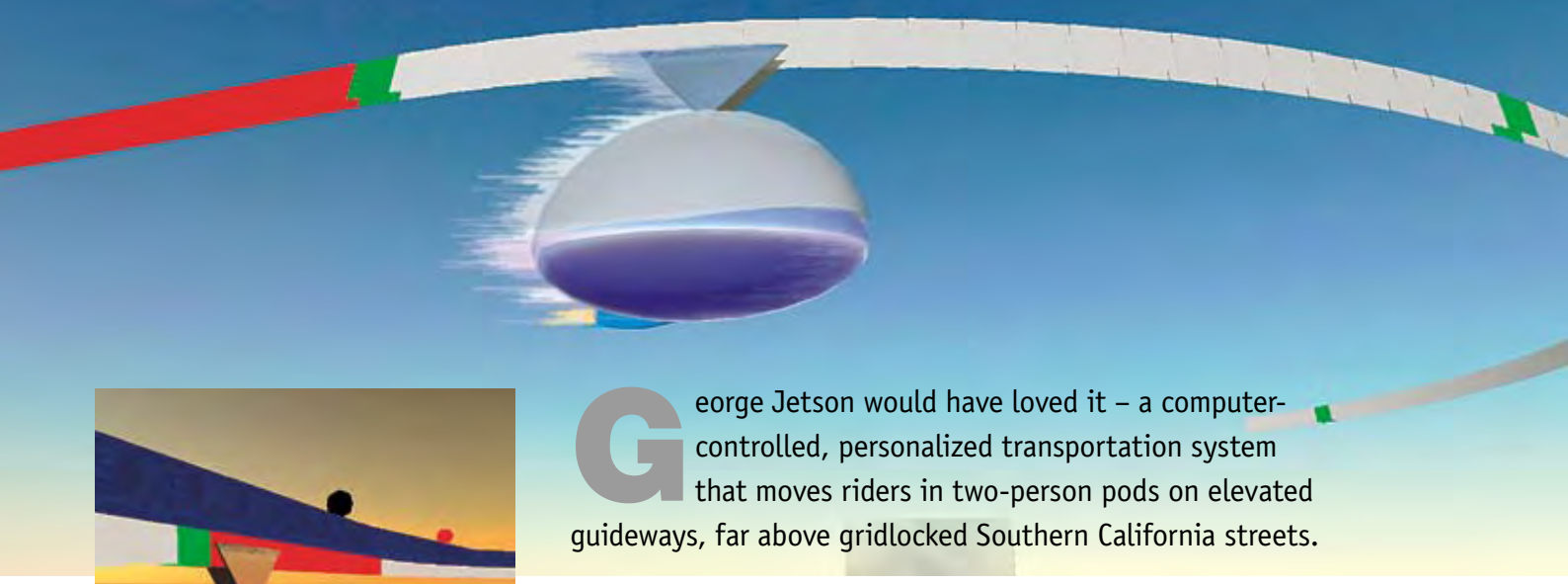
After that, who knows? Says Mjolsness: "We're finding that image analysis can be used for fish and flies, bacteria and more, so there's no reason to stop with plants."

Team members (from left) Pawel Krupinski and Todd Johnson meet with Mjolsness (on right) to discuss results. Above and opposite: Views of the plant meristem, a dome-shaped layer of cells. Scientists "mesh" the images to define simpler geometric units that are easier to manipulate in computing.

Photo: Gregory Gallardo

Driving Miss Avatar

Calit2 Professor Takes Futuristic Transportation System Online



George Jetson would have loved it – a computer-controlled, personalized transportation system that moves riders in two-person pods on elevated guideways, far above gridlocked Southern California streets.

by Anna Lynn Spitzer

A local company is designing the futuristic system and Crista Lopes, a Calit2 researcher, is modeling its logic-control layer on virtual world Second Life.

A Trial Run

Simulations provide a valuable way to test complex engineering systems, says Lopes, associate professor of informatics. "Most engineering systems today have a very strong software component. With respect to the design decisions you make when you are creating software, it's a real advantage to test them in this kind of environment."

Lopes and students Lorraine Kan and Anton Popov are developing and testing the software that will prevent the magnetically-levitated vehicles from colliding as they merge on and off the overhead roadway. Lopes also hopes to build and test the networking system that will allow passengers to direct the pods to a specific location.

She began working last summer with executives from Unimodal Inc., the developer of the system it calls SkyTran. "We met Crista and she suggested this really out-of-the-box, cool way to [simulate] it," says Christopher Perkins, Unimodal CEO.

"Personal Rapid Transit is an old idea that has shown promise and now, because of all the concerns about the environment and the search for alternative forms of energy and transportation, it is being revisited," Lopes says. "It's exciting to be involved with that."

Networking Power

Sky Tran is powered by electricity, with each vehicle getting the equivalent of more than 200 miles per gallon of gasoline. Passengers board at small portals located every quarter mile along a route. After selecting a destination via voice command or touch screen input, they are whisked along at more than 100 miles per hour in the driverless vehicles, avoiding waits, fixed routes and timetables.

For now, Lopes is constructing the model in "Canto Bay," her Second

"She suggested this really out-of-the-box, cool way to [simulate] it."

Courtesy of Unimodal, Inc.

Life work site. A white brick suspended above the station platform is the "track rezzer," a virtual computer that holds the custom software that builds the rail brick by brick.

A blue oval object contains software that runs the station controller – the program that coordinates the vehicles' movement on the track.

"It's like having a robot that creates the model automatically," she explains. "We're doing this with sufficient realism to be able to model the basic station controllers."

Useful Feedback

She and Unimodal executives hope to expand the project. They envision up to 10 stations and many more cars in a more complex network. Second Life visitors could actually travel on the system, creating an online test bed.

Just like Lopes' current effort, the larger model will allow Unimodal designers to make necessary engineering adjustments before deploying the system in the real world.

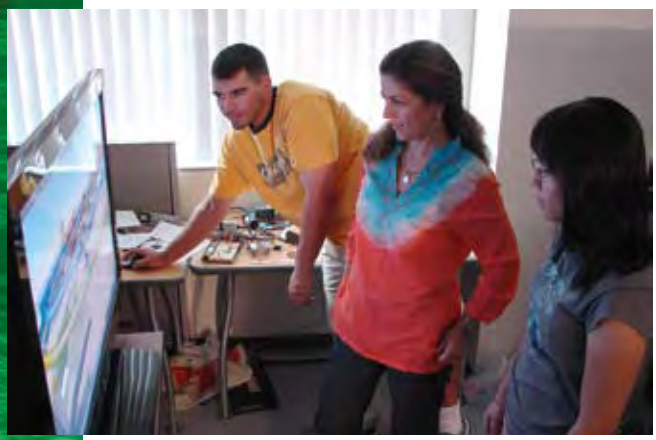


Photo: Gregory Gallardo

Left: SkyTran riders will board the system at modular portals. Above from left: Popov, Lopes and Kan model the system's logic control layer.

The company plans to build a prototype of the system – a 1,000-ft. oval track – by the end of next year.

"This Second Life simulation is already providing feedback to the SkyTran engineers about their design decisions," Lopes says. "As it expands, it can give insights into how successful this technology might be in real life."

Fellows SURF into Summer Research

Editor's Note: *Seven talented UCI students participated in the 2007 Calit2-Emulex SURF-IT (Summer Undergraduate Research Fellowship in Information Technology) program, experiencing the rewards of hands-on research in a multidisciplinary environment. Following are brief, first-person accounts of their diverse projects.*

Phillip Haralson: Using Needle Contacts to Improve Switching Rates of Carbon Nanotube Transistors

We have become increasingly dependent on electrical computers that rely on millions of transistors working together. As we continue to demand greater performance, the size of these transistors must continue to get smaller, pushing the physical limits of conventional silicon transistors. Semi-conducting carbon nanotube field effect transistors (CNT-FETs) – approximately 60 times smaller than the state-of-the-art transistors – may provide a means to continue shrinking the size of these components, but their operating voltages are far higher than theoretically predicted. This performance loss may be a direct result of the relatively large metal electrodes typically used to interface with carbon nanotubes. Working under the guidance of Professor Phil Collins, my research focused on using electron beam lithography and electrochemical deposition to create needle-like contacts to interface with the CNT-FETs. Our hope is that these tiny contacts will dramatically decrease the voltage required for successful operation.

Samuel Kaufman: Nomatic*IM

The research community has developed technology that can reason about a person's position in geographic coordinates. But users might prefer higher-order systems that can reason about places using colloquial terms, like 'Langson Library' or 'home.' We intend to solve this position-to-place problem by gathering place descriptions from a broad array of users whose mobile devices can also record their formal geographic positions. A desktop software system called Nomatic*IM uses machine learning techniques and aggregate data from these many position-to-place mappings to help mobile users negotiate their current context with their instant messenger contacts. Professor Donald Patterson and I developed a prototype of Nomatic*IM, based on a well-known predictive model called classification tree or decision tree learning, which is performing much better than previous approaches. In the near future, we plan to deploy the software, perform user studies and extend the software to benefit from the aggregate contributions of its users.

Quin Kennedy: Active Space: Visualizing Motion-Capture Data

The Active Space project pioneered by my SURF-IT mentor Professor John Crawford is a versatile system that, among other things, is designed to allow a performer to "play the space." Through the use of motion tracking via live video feed, the system is able to react to dancers in the space and drive video manipulations and audio synthesis. My research aims to incorporate the ability to analyze 3-D motion capture data, thus providing a much more accurate form of motion analysis. This will add the ability to capture a

higher resolution of movement, the perception of nuances and complexities in movement, and the capacity to take depth into account with greater ease than is possible with 2-D video analysis.

Danish Khan: Nomatic*Aid
During a major crisis, it is imperative that relief workers have reliable communication. However, everyday communication technologies, such as phone lines, are often lost, especially in areas with weak infrastructure. My project, led by Professor Don Patterson, focused on the Nomatic Aid prototype. The project uses camera- and GPS-equipped mobile phones to tag and communicate context-based data. We deployed Nomatic Aid in Africa, where we were surprised to discover a very stable communication infrastructure for mobile phone reception and Wi-Fi. The project turned out to be a success because it communicates information quickly using the infrastructure already provided and will allow us to create an application that will benefit crisis relief workers in third-world countries.

Nathaniel Pope: Beyond Play: Artificial Worlds and Gaming Capital
Multiplayer online role-playing games create environments with real consequences. Players buy and sell virtual items with real money or create machinima – game-generated movies – making real profit. This causes new social and cultural relationships to emerge and the separation of play from productivity seems to disappear. This project, under the direction of Professor Peter Krapp, uses qualitative and quantitative approaches to understand responses to these phenomena from game developers and players, and traces a history of what passes for "play" and what constitutes a "game." Results suggest synthetic worlds have become host to ordinary human interaction, creating intersections between everyday life and the matrix of fiber-optic fantasy lands. Emergent play resists classification as work, but most gaming environments provide viable social, cultural and market reciprocity.

Mark Sueyoshi: Exploring the Role of the Reader in Blogging
Within the last decade, blogs have become an important element of popular culture, mass media, and the daily lives of countless Internet users. Despite the medium's interactive nature, most research focuses on either the blog itself or the blogger, rarely addressing the reader's impact. To gain greater understanding of this social practice, we took into account the role, contributions and significance of the reader. My research with Professor Bill Tomlinson involved an ethnographic study of blog readers that highlights a number of salient themes. Our findings both agree and conflict with previous research and suggest a number of directions and implications for future research on the subject.

Connie Tran: Increasing Girls' Access to Advanced Technology
Though girls use computers as frequently as boys, the ways they use them differ. Boys have more experience with advanced uses of computers that can eventually lead to lucrative careers. This project with Professor Mark Warschauer explored classroom processes that create a positive or negative learning environment for girls exposed to advanced technology. The study focused on extra-curricular classes offered to K-12 students in a community learning center. Data was gathered from observations and interviews of students in four programming and digital media design classes. Relatively few girls chose to enroll in these classes but once enrolled, the girls' experiences and participation varied. The study suggests that specific intervention is required by both administrators and classroom teachers to increase girls' access to creative learning with technology.

Expanding Our Research Realm

Editor's Note: *Sixteen graduate students from a wide range of disciplines concluded their year as Calit2-Emulex graduate fellows. Aniketa Shinde was the group's organizer and Calit2 liaison.*

By Aniketa Shinde

As a 2006-07 Calit2-Emulex Graduate Fellow, I had an opportunity to gain insight into various interdisciplinary projects in progress at UC Irvine and meet students pursuing unique research in fields from physical sciences and engineering to art.

The program kick-off included a meeting with then Calit2@UCI director Albert Yee, who encouraged us to get acquainted with each other and familiarize ourselves with the exciting research we are pursuing. We were given the freedom to plan the year ahead of us, and decided to have monthly meetings at which two fellows would give informal talks about their research.

The challenge for most of us in planning our presentations was to focus on how our specific project furthered Calit2's research goals, while also remembering that our audience was made up of graduate students from a wide range of research areas. The talk needed to be specific enough to address Calit2's goals, while also being general enough to ensure audience understanding. This allowed us to gain experience describing our research to those outside of our specific field, something that is invaluable to interdisciplinary scientific work.

As a student in the chemical and material physics specialization in the physics department, I have been exposed to the various cross-disciplinary areas that relate to physics, such as biology, medicine, engineering and chemistry. Through our informal monthly meetings, I heard about other research areas blending and forming new programs such as ACE (Arts Computation Engineering). Two of the graduate fellows in this program gave very interesting talks about their projects. The personal soundtrack, as described in *Interface* Spring 2007, and GoScape, which was exhibited at the Orange Lounge at South Coast Plaza, use technology and computing to provide a unique music experience.

My colleagues also valued our year as grad fellows.

Eric Baumer organized our Graduate Student Forum on Interdisciplinary Research and considers that a highlight of his fellowship experience.

"I thought it was a great way to see how different disciplines defined their boundaries, research questions of interest and methodologies, and it also helped provide fresh perspectives and novel insights," he said.

Pablo Diaz-Gutierrez spoke for many of us when he said, "Receiving the fellowship helped ease the pain of graduate student life …and gave me time to concentrate on my research. The presentations by other students were varied and interesting, and allowed me to learn about techniques and areas of study that I wouldn't have heard of otherwise."

A Vote of Confidence

In an effort to better understand the state's investment in creating and supporting Calit2, numerous elected officials visited UCI recently. State representatives Mimi Walters (R-73rd District), Jim Silva (R-67th District) and John Moorlach from the Orange County Board of Supervisors paid separate visits to see firsthand the unique institute/industry research partnerships that accelerate the development of new information and technologies. Lawmakers participated in lab demonstrations and learned more about the creative strategies that improve technology transfer, speeding downstream commercialization of research discoveries.

Assemblywoman Mimi Walters (center) and her chief of staff, Gina Zari, listen to Chris Davison, technology resource manager, describe Project ResCUE's disaster-preparedness activities.

Assemblyman Jim Silva (center), flanked by UCI alumni board representatives Ed and Serafina Raskin, views the Evac-Pack, one of several IT prototypes being developed for first-responders.

OC Supervisor John Moorlach (left) and Assistant Professor Steve Jenks pause for a moment in front of Calit2's HIPerWall.

Ask the TIPSter

***TIPS** (Taking IP to Startup) is a new service offered by Calit2@UCI 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.*

Creating a successful startup can be a challenge. There are many factors to consider, such as the market, the business model, startup financing and so on. How can a non-seasoned business person or university researcher begin to understand and overcome all the challenges to create the next Google (Stanford), nicotine patch (UCLA) or Genentech (UCSF)? TIPS will try to answer some of your questions.

I have an idea for a company based on my university research; where do I start?

The first thing you will need to do as an inventor is disclose the invention to the university by completing the Confidential Disclosure and Record of Invention form *(www.ota.uci.edu/forms/roiform.doc)* and submitting the original to the Office of Technology Alliances. Once a case number is opened and OTA licensing professionals have determined the invention is patentable, you may schedule a meeting with one of the OTA staff to discuss the next steps, namely the startup company licensing the invention from the university.

How important is a business plan? How do I write one?

A business plan describes a company's course of actio n for achieving its goals and objectives over a set amount of time. For startup companies, the plan should detail the market problem to be solved, proposed products, market size, potential industry, marketing approach, management team, product development plan, production needs, financial plan and risks. While this sounds daunting, a good place to start is with a short summary that describes the problem, the solution and the potential size of the market.

Who is the first person to convince that this good idea will make a great startup company?

The first person you have to convince (other than yourself) is the first team member who will join you and bring complementary skills to the effort. Every great technology-based company has a great chief executive officer and a great chief technology officer. In very few cases is this the same person. Building great companies takes teams of great people.

What else do I need to know?

We will cover some financing questions in the next issue. If you have any specific questions, please ask us! We hope that this column will become an interactive forum where we can answer your questions. Email them to tips@calit2.uci.edu. TIPS also has open office hours 1-5 p.m. every Thursday and 1-4 p.m. the first and third Tuesday of each month in the Calit2 Building, room 4106. Please feel free to stop by and get the advice you need in person.

OCTANe (www.octaneoc.org) works with Orange County's leading biomedical and information technology companies, promising startups, entrepreneurs, venture capitalists and universities to create, grow and fund innovative companies.

OCTANe LaunchPad director Luis Vasquez helps entrepreneurs and startup companies take advantage of OCTANe's resources and networks to get funded and achieve their early milestones. As of last month, he had helped 20 LaunchPad companies raise more than $40 million.

The Office of Technology Alliances (www.ota.uci.edu) fosters faculty/industry alliances and commercialization of UC Irvine technology, emphasizing accessibility, timeliness and flexibility.

Breaking News, Making News

by Shellie Nazarenus

Maria Feng, a.k.a the Bridge Doctor, talks with Jennifer Bauman from KOCE-TV.

If you turned on your TV or picked up a newspaper during the past few months, you probably saw some of Calit2's next-generation research featured. News media outlets – national and regional – spent a lot of time at the UCI Calit2 Building earlier this fall covering two different projects.

In the wake of the Minneapolis bridge collapse, reporters sought the expertise of Calit2 academic affiliate Maria Feng, a professor of civil and environmental engineering, who designs and studies the use of fiber-optic sensors to monitor the health of large civil infrastructures, such as bridges and buildings. Known as the "Bridge Doctor," Feng has patented sensors that are smaller, lighter and more resilient to harsh weather conditions than standard electric sensors. Her bridge research, funded by Caltrans, also employs strain sensors embedded into the concrete, accelerometers, displacement sensors and soil pressure sensors that can detect problems visual inspections can miss. NBC Nightly News featured Feng and her team at work in their Calit2 lab, as well as traveling to the Vincent Thomas Bridge in Long Beach, which they are monitoring as part of their research. KOCE-TV, as well as KFWB and KPCC radio, and numerous newspaper outlets also interviewed Feng.

CNN Reporter Christopher Lawrence went live from Calit2 for the "American Morning" news program.

Considered one of the world's highest-resolution display walls, the HIPerWall drew international media coverage. CNN's news show "American Morning" featured a live feed from Calit2's Center of GRAVITY, which houses the 200-million-pixel tiled display. The *Los Angeles Times* featured the research team, led by Stephen Jenks, assistant professor of electrical engineering and computer science. And Univision, the largest Spanish-language television station in the United States, reported to audiences in multiple countries.

An international audience tuned in to Univision correspondent Magaly Ortiz's report about the HIPerWall.

The HIPerWall offers a view 100 times more detailed than any high-definition monitor on the market today. While the gee-whiz factor certainly caught the audience's attention, it was the wall's unique and diverse research capabilities that delivered a powerful message. From viewing damage wrought by Hurricane Katrina to mapping earthquakes in South America to studying patients suffering from brain diseases, HIPerWall showed off its ability to display the big picture and the fine detail at the same time.

Next Major Internet Transformation

Point-and-click access to the Worldwide Web is a mere 10 years old, having been ushered in by Netscape's 1997 Beta-version browser. User demand for more robust interaction followed, giving birth to Web 2.0 and the rise of interactive applications. Today, the Web is on the threshold of an even more connective and user-responsive environment. Web 3.0 encompasses virtual spaces, massively multiplayer online games and augmented reality that once again will change the way consumers and corporations utilize the Internet. Guided by a panel of gaming experts, a standing-room-only audience experienced the Web's future at last summer's Igniting Technology presentation, sponsored by Knobbe Martens. An audience from Daegu City, Korea joined the event via high-speed video teleconferencing. The Korean researchers are partnering with the Game Lab to develop networks, devices, tools and techniques for beyond-next-generation online games.

Swedish Delegation Pays a Visit

A delegation from the Swedish Consulate in Los Angeles visited the Irvine division in September after learning of Calit2's research. Staff from the Office of Science and Technology expressed interest in touring the facility after seeing an article about the HIPerWall in *Ny teknik,* a Swedish weekly newspaper that covers technology *(http://www.nyteknik.se/art/45148)*. Delegates met visualization and gaming researchers, and toured several labs. The Science and Technology office monitors U.S. IT-related trends, looking for potential partnerships in next-generation technologies.

Future Direction Under Discussion

Looking to the future, Calit2's Advisory Board met in July at the Irvine division to review the two-campus institute's research priorities. The national board is comprised of academic, government and industry leaders who offer strategic guidance and support to advance Calit2's mission. Special focus was given to ongoing work in the areas of intelligent transportation and hydrology. The group agreed that further emphasis should be given to information technology research as it relates to the environment and resource management. In addition, board members were apprised of the operational and budgetary challenges facing the institute, which now has dedicated facilities at UCI and UC San Diego. The annual meeting followed a comprehensive five-year external review of the institute's progress.

UC Fellows Discover Calit2

Much like the mission of Calit2, the UC Discovery Industry-University Cooperative Research Program (IUCRP) was established to enable and extend partnerships between academia and industry that can fast-track research and development into the state's economy. The IUCRP offers year-long fellowships to select UC researchers and administrators. Earlier this summer, the nine 2006-07 fellows concluded their term by visiting Calit2@UCI to learn more about projects in the building that involve faculty and student research teams working with industry partners. The group toured several labs, getting hands-on exposure to some of the prototypes under development.

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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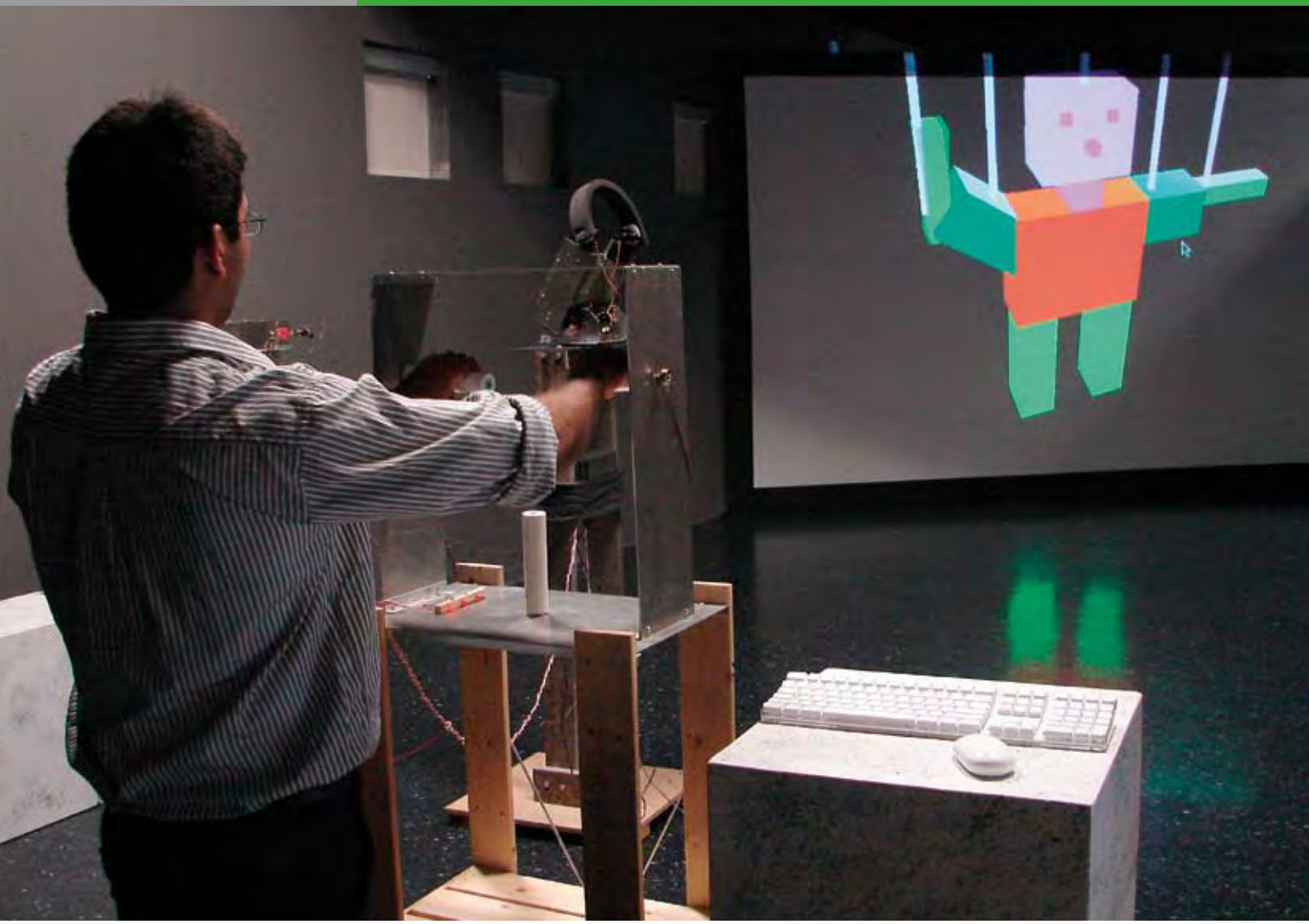

Photo: Gregory Gallardo

Art, computation and engineering converged in a unique exhibit in the Calit2 Building last month. Seven students in the ACE multidisciplinary graduate program presented "Interfaced: Mediating Techno-Cultural Practice," a collection of their first-year projects. Among them: a custom-designed beehive outfitted with electronic hardware and sensor technology; a digital sandbox filled with silicon "sand" that allowed participants to communicate with each other; a five-character game driven by artificial intelligence; and a drum set/interactive web site combination that permitted participants around the globe to make music together and watch their performance on streaming video.

Karan Kamdar (pictured) created an electromechanical puppet that interacted with and influenced the audience via a control panel. The show, said one student was "an important and integral step towards our training as interdisciplinary artists, engineers and scientists."