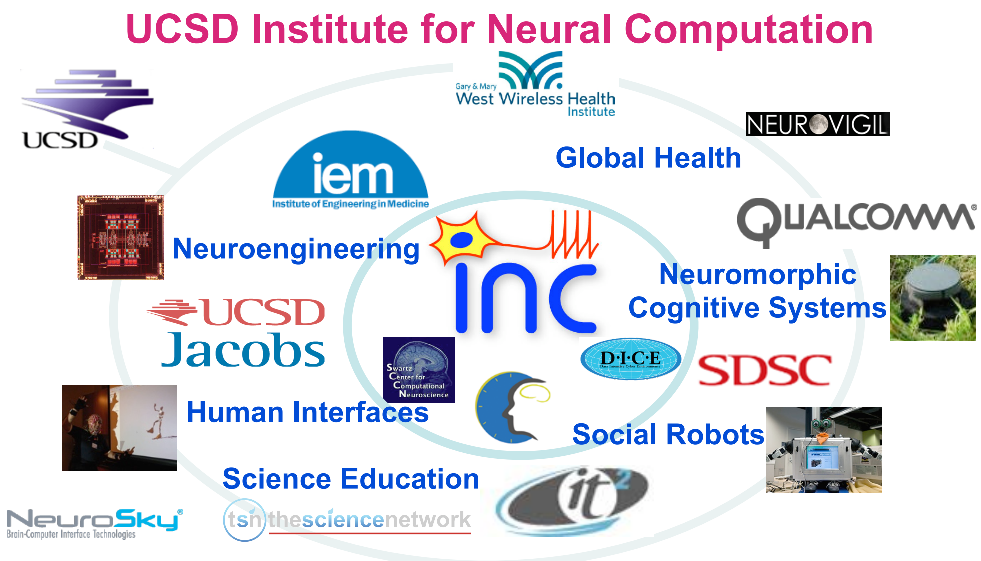
INCubator

SCCN and INC Open House

The Swartz Center for Computational Neuroscience (SCCN) and its parent Institute for Neural Computation (INC) have moved into new quarters in the recently completed extension of the San Diego Supercomputer Center on the UCSD campus. On Thursday, March 4, the Swartz Center held a brief opening ceremony followed by a joint INC/SCCN Open House which featured opening talks by Institute Co-Directors Terrence Sejnowski and Gert Cauwenberghs on the past and future of the Institute.



The mission of INC is to bring together the diverse research community in the basic sciences, medical, and engineering disciplines at UCSD in advancing and promoting a new science of computation and learning, based on the multiscale, parallel, and highly adaptive architectures found in biological neural systems. INC is committed to worldwide leadership in its research and to work with industrial/clinical partners and the broader community in applying research advances to the benefit of society.

Co-Director Terrence Sejnowski shared the relevance of the research: "The field of neural computation is beginning to touch many many many other areas. It's beginning to touch education, it's beginning to touch medicine ... and it's clear that it's not just an island unto itself." Co-Director Gert Cauwenberghs also stated how the interdisciplinary nature of the research done at UCSD INC makes it "increasingly important to connect to the outside community ... also there's some very interesting developments today in global health and wireless health."

Demonstrations of new research technology followed which included laptop based facial expression monitoring (Marni Bartlett), the IRODS distributed database system (DICE Group), and human motion capture (Howard Poizner) from INC, and brain-computer interface methods (Thorsten

Continued on page 7

ARTICLES INSIDE:

Terrence Sejnowski Elected to National Academy of Sciences

Salk Institute professor Terrence J. Sejnowski, Ph.D., whose work on neural networks helped spark the neural networks revolution in computing in the 1980s, has been elected a member of the National Academy of Sciences.

A Howard Hughes Medical Institute investigator, Dr. Sejnowski tries to understand the computational resources of brains, and to build linking principles from brain to behavior using computational models. He pursues his goal by combining both experimental and modeling techniques to study the biophysical properties of synapses- the connections between brain cells- and the population dynamics of large networks of neurons.

Dr. Sejnowski uses these computational models to develop large-scale computer models to study how the human brain is able to learn and store memories. This knowledge ultimately may provide medical specialists with critical clues to combating Alzheimer's disease and other disorders that rob people of the critical ability to remember faces, names, places and events.

Full article available at:

http://www.eurekalert.org/pub_releases/2010-04/si-sst042710.php

INC at a glance

Institute for Neural Computation (INC)
http://www.inc.ucsd.edu
Terrence Sejnowski and Gert Cauwenberghs, Co-Directors
Shelley Marquez, Executive Director

Swartz Center for Computational Neuroscience at INC
http://www.sccn.ucsd.edu
Scott Makeig and Tzyy-Ping Jung, Co-Directors

Machine Perception Laboratory at INC
http://mplab.ucsd.edu/
Javier Movellan, Marian Stewart Bartlett, and Glen Littlewort, Principal Investigators

Temporal Dynamics of Learning Center (TDLC) Motion Capture/Brain Dynamics Facility at INC
http://inc.ucsd.edu/~poizner/motioncapture.html
Howard Poizner and Scott Makeig, Co-Directors

Office of Naval Research (ONR) Multidisciplinary University Initiative (MURI) Center
http://inc.ucsd.edu/~poizner/onr_muri/
Howard Poizner, UCSD (PI); Gary Lynch, UCI (Co-PI); Terrence Sejnowski, Salk Institute/UCSD (Co-PI)

Mobile Brain Imaging Laboratory (MoBI) at INC
Scott Makeig, Principal Investigator

Poizner Laboratry at INC
http://inc2.ucsd.edu/poizner/
Howard Poizner, Principal Investigator

Dynamics of Motor Behavior Laboratory at INC
http://pelican.ucsd.edu/~peter/
Peter Rowat, Principal Investigator

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Lessons from RUBI

Researchers from around the world are developing cognitive social robots to interact with and engage humans in a variety of activities: from teaching them simple skills to performing household skills.

While programmed to perform and adapt to a number of tasks, these social robots may not appear even remotely humanlike in appearance. Built from less than $200 plus the cost of a laptop, RUBI from the Machine Perceptron Laboratory at the University of California, San Diego is one such robot.

RUBI looks like a desktop computer come to life: its screen-torso, mounted on a pair of shoes, sprouts mechanical arms and a lunchbox-size head, fitted with video cameras, a microphone and voice capability. RUBI wears a bandanna around its neck and a fixed happy-face smile, below a pair of large, plastic eyes.

In the San Diego classroom where RUBI has taught Finnish, researchers are finding that the robot enables preschool children to score significantly better on tests, compared with less interactive learning, as from tapes.

Preliminary results suggest that these students "do about as well as learning from a human teacher," said Javier Movellan, director of the Machine Perception Laboratory at the University of California, San Diego. "Social interaction is apparently a very important component of learning at this age."

Like any new kid in class, RUBI took some time to find a niche. Children swarmed the robot when it first joined the classroom: instant popularity. But by the end of the day, a couple of boys had yanked off its arms.

An early phase of the RUBI project was tested with toddlers in 2005 at the University of California, San Diego.
(Photo by Alan Decker)

"The problem with autonomous machines is that people are so unpredictable, especially children," said Corinna E. Lathan, chief executive of AnthroTronix, a Maryland company that makes a remotely controlled robot, CosmoBot, to assist in therapy with developmentally delayed children. "It's impossible to anticipate everything that can happen."

The RUBI team hit upon a solution one part mechanical and two parts psychological. The engineers programmed RUBI to cry when its arms were pulled. Its young playmates quickly backed off at the sound.

If the sobbing continued, the children usually shifted gears and came forward — to deliver a hug.

Re-armed and newly sensitive, RUBI was ready to test as a teacher. In a paper published last year, researchers from the University of California, San Diego, the Massachusetts Institute of Technology and the University of Joensuu in Finland found that the robot significantly improved the vocabulary of nine toddlers.

After testing the youngsters' knowledge of 20 words and introducing them to the robot, the researchers left RUBI to operate on its own. The robot showed images on its screen and instructed children to associate them with words.

After 12 weeks, the children's knowledge of the 10 words taught by RUBI increased significantly, while their knowledge of 10 control words did not. "The effect was relatively large, a reduction in errors of more than 25 percent," the authors concluded.

"It turns out that making a robot more closely resemble a human doesn't get you better social interactions," said Terrence J. Sejnowski, a

Continued on page 4

Lessons from RUBI (continued)

neuroscientist at University of California, San Diego. The more humanlike machines look, the more creepy they can seem.

The machine's behavior is what matters, Dr. Sejnowski said. And very subtle elements can make a big difference.

The timing of a robot's responses is one. The San Diego researchers found that if RUBI reacted to a child's expression or comment too fast, it threw off the interaction; the same happened if the response was too slow. But if the robot reacted within about a second and a half, child and machine were smoothly in sync.

If robots are to be truly effective guides, in short, they will have to do what any good teacher does: learn from students when a lesson is taking hold and when it is falling flat.

Full article available at:

http://www.nytimes.com/2010/07/11/science/11robots.html?pagewanted=1

Howard Poizner and Team Awarded $4.5M ONR MURI Grant -- "How Unsupervised Learning Impacts Training: From Brain to Behavior"

Howard Poizner (PI, UCSD), and co-PI's Gary Lunch (UC Irvine) and Terry Sejnowski (Salk and UCSD), together with team leaders Hal Pashler, Sergei Gepshtein, Deborah Harrington, Tom Liu, Eric Hlagren, and Ralph Greenspan were recently awarded a $4.5M ONR MURI grant, with a $3M option period, to study the brain bases of unsupervised learning and training.

The goal of this multidisciplinary grant is to examine the neurobiological, genetic, brain dynamic, and neural circuit correlates of unsupervised learning and training. The proposed studies utilize the new capabilities for creating 3D immersive environments and simultaneous EEG-fMRI recordings.

The cerebral cortex is able to create rich representations of the world that are much more than just reinforcement learning and reflexes. Learning is often self-supervised without feedback, a type of learning referred to as unsupervised learning. Such learning, and memory, is (i) commonplace in naturalistic settings, (ii) critical to humans, (iii) encoded by LTP-type mechanisms, and (iv) of direct relevance to computational theories of learning. Using unsupervised learning, an individual builds up internal hierarchical structures and categorizations that model the statistical properties of the environment. These internal representations can be used flexibly and

The suit for the 3D immersive environment.

Continued on page 5

Howard Poizner and Team Awarded $4.5M ONR MURI Grant -- "How Unsupervised Learning Impacts Training: From Brain to Behavior" (continued)

fMRI studies of the brain during 3D immersive environment activities

powerfully to acquire new information thereby creating situational awareness and readiness to act in novel as well as in familiar environments. Yet, unsupervised learning and its neurobiological mechanisms are poorly understood.
Our proposed projects will provide new understanding of the neurobiological, genetic, brain dynamic, and neural circuit correlates of this potentially powerful form of learning and training. We propose seven tasks that attack different aspects of the problem making use of parallel paradigms in rodents, flies, and humans. Task 1 maps memory during spatial learning in rats, seeking to uncover the neural engram of memory. Task 2 uses computational modeling to illuminate cortical processes of unsupervised learning in humans. Task 3 conducts studies of training, contrasting the rate and efficiency of both unsupervised and supervised learning. Task 4 explores the brain dynamics of unsupervised learning, using motion capture and virtual environments while recording cortical EEG. Tasks 5 and 6 investigate neuroimaging and genetic correlates of unsupervised learning bringing to bear the new methodology of simultaneous EEG-fMRI recording and using intracranial recordings. Finally, Task 7 exploits the genetic cellular, and behavioral homologies of the fruit fly with humans to study the dopaminergic and genetic regulation of inter-regional coherence associated with learning.

These studies should provide insight into design of the best training environments for our modern military, and increase our understanding of the underlying neurobiological, genetic, brain dynamic, and neural circuit correlates of those environments. Moreover, the studies will open the way to asking if memory enhancing drugs such as ampakines or if particular learning regimens (e.g., extensive experience with diverse environments, short vs. long sessions) change the number and/or distribution of learning-related synaptic modifications and/or the nature of the neural networks and brain dynamics that underlie unsupervised learning. This issue is fundamental to development of mechanism-based strategies for improving learning and performance in complex environments. Finally, the genetic studies will pave the way for development of individualized training techniques that optimize learning environments.

Full article available at:

http://tdlc.ucsd.edu/press/pressroom-awards-onr-muri.html

Gert Cauwenberghs and Team awarded DARPA Neovision2 Grant -- Neuromorphic Modular and Evolvable Vision Systems

A team of leading neuroscientists and neuroengineers at Evolved Machines, MIT, UC Berkeley, UC San Diego, Stanford, Imagize, and nVidia received a $6.7M Phase 1 grant from DARPA as part of its Neovision2 program towards reverse engineering and emulating the mammalian visual system, from retina to visual cortex, to revolutionize the underlying technologies for unmanned sensor systems.

As part of this effort the UC San Diego team at INC, led by Gert Cauwenberghs in the Integrated Systems Neuroengineering Laboratory of the Department of Bioengineering and with Terry Sejnowski at the Computational Neurobiology Laboratory at the Salk Institute, will pursue neuromorphic implementation of the retinal and cortical models in hybrid analog-digital silicon microcircuits with unprecedented functional flexibility and energy efficiency.

The enabling technology in the INC approach is a scalable 3-D silicon integrated circuit architecture to realizing locally dense and globally sparse connectivity in large-scale reconfigurable neuromorphic systems, towards real-time and low-power implementation of neocortical vision with over a million neurons and a billion synapses. The INC cortical neuromorphic system will be the first to implement multi-compartmental models of branched nonlinear neural integration, conductance-based synaptic dynamics, and homeostatic synaptic plasticity, throughout all stages of visual pathways as experimentally observed in detail by the multi-university neuroscience team, in a fully programmable and reconfigurable network.

In Phase 2 the INC team will progressively scale up the network, at sustained dendritic arbor and synaptic fan-in/out densities, in a multi-module cortical system. INC will further develop and implement the first silicon retina microchip to model the detailed spatiotemporal response of 8 types of ganglion cells in a programmable event-based interface.

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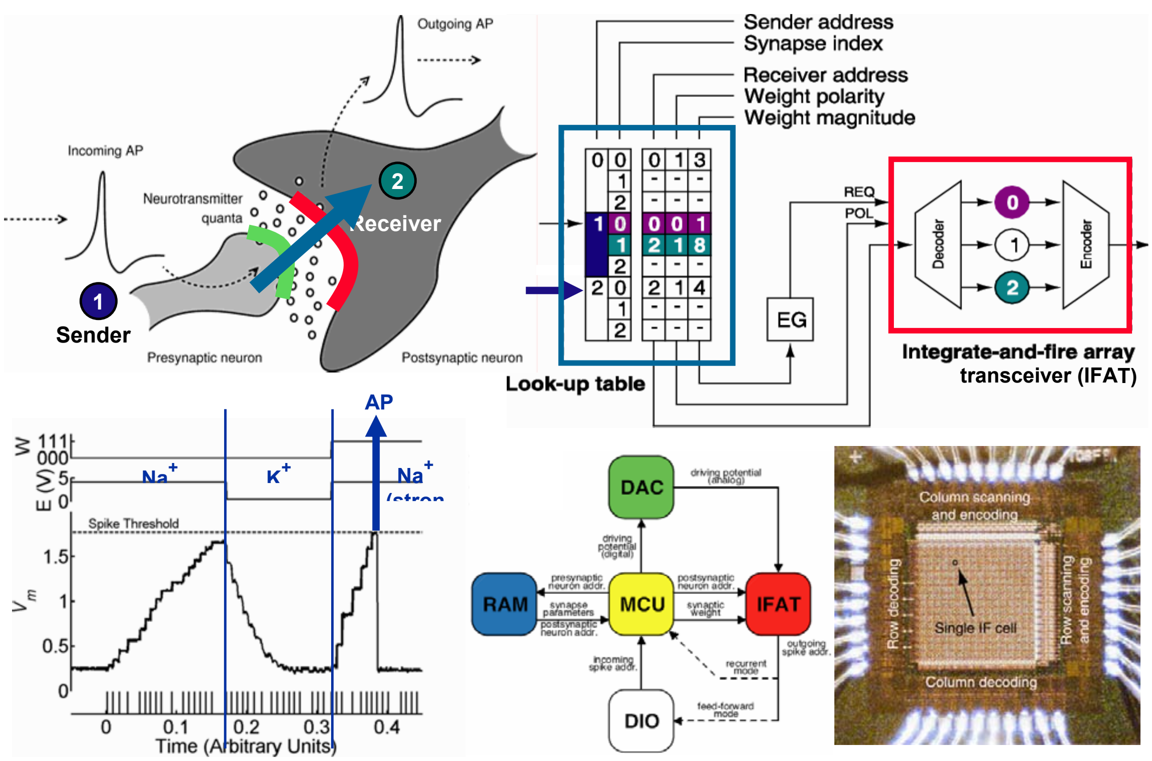

Large-scale network emulation of neural computation with general, reconfigurable synaptic connectivity and spike-timing dependent plasticity [Vogelstein et al, 2007a]. Action potetntial (AP) events are routed through a synaptic table, and update entries in the synaptic table are based on relative timing of presynaptic and postsynaptic AP events. The multichip system implements various forms of spike timing dependent plasticity (STDP) [Bi and Poo 1998, Vogelstein et al, 2004].

Gert Cauwenberghs and Team awarded DARPA Neovision2 Grant -- Neuromorphic Modular and Evolvable Vision Systems (continued)

In Phase 3, the retinal sensing and cortical recognition multi-chip systems will be integrated in a final 10W, 10kg, 0.1m2 standalone demonstration platform, bootstrap-configured using the GPU/FPGA benchmark, further trained and evolved on standard visual object databases, and evaluated for detection of visual targets in the field. The explanatory power of the system to replicate neuroscience data at various stages throughout the visual system, using the same array of structured and natural visual input patterns presented to the live and artificial retina, will also be evaluated.

Read more:

R.J. Vogelstein, U. Mallik, J.T. Vogelstein, G. Cauwenberghs. "Dynamically reconfigurable silicon array of spiking neurons with conductance-based synapses," *IEEE Transactions on Neural Networks*, 18(1); 253-265, 2007.

G-Q Bi, M-M Poo. "Synaptic modifications in cultured hippocampal neurons: dependence on spike timing, synaptic strength, and postsynaptic cell type," *Journal of Neuroscience*, 77:551-555, 1998.

R.J. Vogelstein, U. Mallik, and G. Cauwenberghs. "Silicon spike-based synaptic array and address-event transceiver," *2004 IEEE International Symposium on Circuits and Systems,* Vancouver, BC, Canada, May 2004.

SCCN and INC Open House (continued)

Andrey Vankov demos DataRiver - a software platform for real-time management of multiple data streams

Zander), wireless dry electrode EEG monitoring (Tzyy-Ping Jung, Yijun Wang), experimental real-time interactive control and analysis (ERICA) software (Andrey Vankov), and mobile brain/body imaging (Scott Makeig) from SCCN.

SCCN Center director Scott Makeig and Associate Director Tzyy-Ping Jung say that the new, larger space will enable SCCN to continue to grow in size and diversity and the co-location of SCCN and INC will allow more effective interactions between researchers and campus faculty collaborators.

In addition to facilitating increased collaboration between researchers, the new Center now houses the mobile brain/body imaging (MoBI) laboratory. The new lab features high-density portable EEG and full-body motion capture, plus a sophisticated multi-channel audiovisual display and recording system, high-tech control room, and novel ERICA software allowing complex experiments involving one or more subjects acting or interacting in normal 3-D environments.

Another technology being pioneered by the Swartz Center is wireless dry electrode EEG (brainwave measuring) systems. Associate Director Tzyy-Ping Jung points out that the major obstacle to using EEG to routinely monitor our cognition and brain function, either for medical or human-system interaction purposes, has been the lack of convenient-to-use dry electrode systems.

Co-Director Terrence Sejnowski states it "has been wonderful about UCSD and the organized research units that they have deployed ... [that]

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SCCN and INC Open House (continued)

creating new science is always at the borders between these disciplines and having the ability to create these new research units and have them evolve and shift in exactly the way that we started by shifting from an institute for cognitive science into an institute for neural computation was a new look at an old problem but one that led in a completely new direction."

Full article available at:

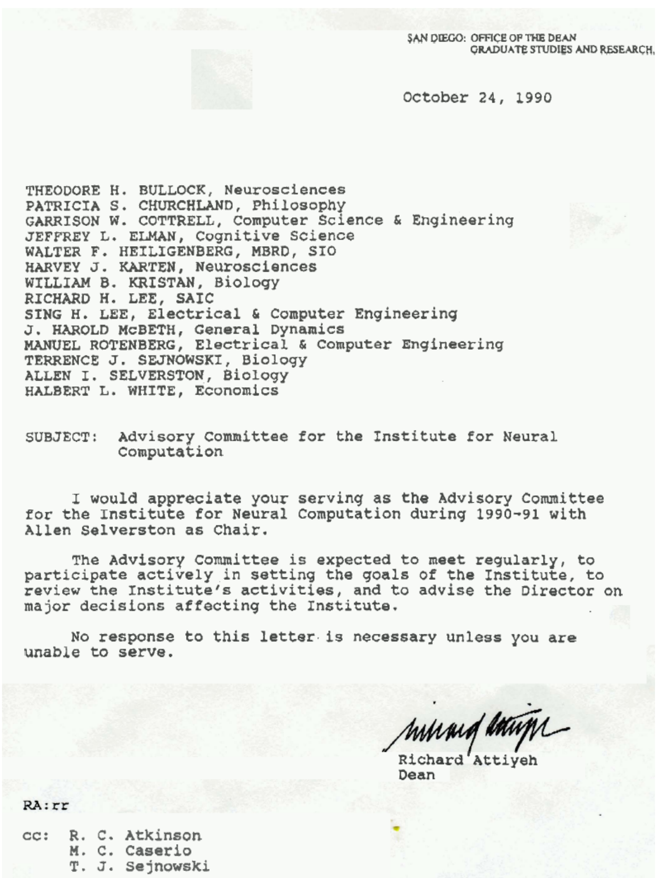
http://sccn.ucsd.edu/events/reopening.html

Presentation videos and highlight reel available at:

http://thesciencenetwork.org/programs/inc-sccn-open-house

http://thesciencenetwork.org/programs/inc-sccn-open-house/inc-sccn-open-house-hi-lite-reel

Swartz Foundation founder Jerry Swartz recalled SCCN history during the opening ceremony.



SAN DIEGO: OFFICE OF THE DEAN
GRADUATE STUDIES AND RESEARCH

October 24, 1990

THEODORE H. BULLOCK, Neurosciences
PATRICIA S. CHURCHLAND, Philosophy
GARRISON W. COTTRELL, Computer Science & Engineering
JEFFREY L. ELMAN, Cognitive Science
WALTER F. HEILIGENBERG, MBRD, SIO
HARVEY J. KARTEN, Neurosciences
WILLIAM B. KRISTAN, Biology
RICHARD H. LEE, SAIC
SING H. LEE, Electrical & Computer Engineering
J. HAROLD McBETH, General Dynamics
MANUEL ROTENBERG, Electrical & Computer Engineering
TERRENCE J. SEJNOWSKI, Biology
ALLEN I. SELVERSTON, Biology
HALBERT L. WHITE, Economics

SUBJECT: Advisory Committee for the Institute for Neural Computation

I would appreciate your serving as the Advisory Committee for the Institute for Neural Computation during 1990-91 with Allen Selverston as Chair.

The Advisory Committee is expected to meet regularly, to participate actively in setting the goals of the Institute, to review the Institute's activities, and to advise the Director on major decisions affecting the Institute.

No response to this letter is necessary unless you are unable to serve.

Richard Attiyeh
Dean

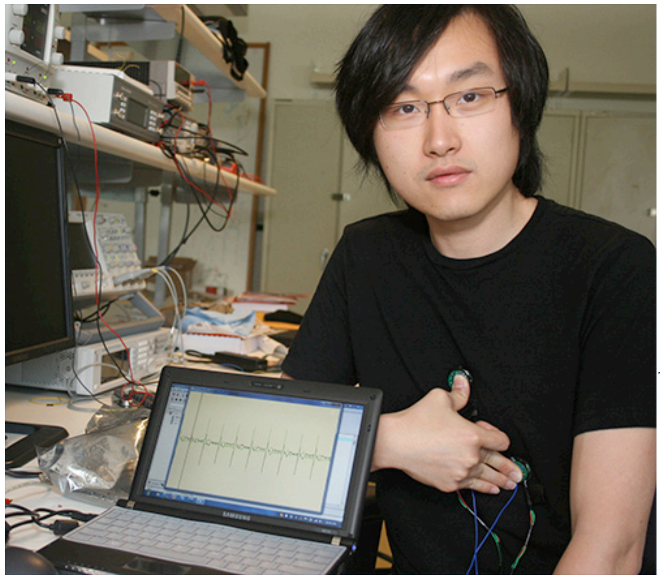
RA:rr

cc: R. C. Atkinson
M. C. Caserio
T. J. Sejnowski

The letter from Dean Attiyah in 1990 granting license to form an advisory committee for the INC and its original members.

UCSD Entrepreneur Challenge

Wireless sensors that monitor your heart even though they do not actually touch your skin are at the center of UC San Diego electrical engineering PhD student Yu Mike Chi's dissertation. This technology – and the plan for commercializing it – earned Chi and his Cognionics team the top spot in the UC San Diego Entrepreneurship Challenge. The prize includes $25K in cash for the startup and $15K in legal services.



Wireless sensors that monitor your heart even though they do not actually touch your skin (shown above) are at the center of UC San Diego electrical engineering PhD student Yu Mike Chi's dissertation. This technology – and the plan for commercializing it – earned Chi and his Cognionics team the top spot in the UC San Diego Entrepreneur Challenge. More photos on the Jacobs School blog.

Engineers and physicians are increasingly looking to wireless technologies and innovative circuit designs to develop sensors that cut health care costs through better preventative care and shorter hospital stays. Wireless sensors also offer patients more freedom than wired sensors hooked to machines. Chi's wireless sensor project could lead to unobtrusive heart sensors for long term cardiac health monitoring that do not touch the skin and do not tether patients to machines.

The sensors record "biopotentials" – tiny voltage signals that appear on the skin surface. Biopotentials emanate from electrically active cells, such as neurons and cardiac cells, and propagate through the conductive media of the human body.

At the final phase of the 2009-2010 UC San Diego Entrepreneur Challenge, on June 2, Chi gave a 12 minute presentation of the Cognionics business plan to the panel of judges, followed by an 8 minute question-answer period. When the Q&A finished with a few minutes to spare, Chi quickly set up a live demo. Pressing the sensor into his chest, over his clothes, the electrical activity of his heart appeared on the giant presentation screen.

Chi is developing this technologies under the guidance of professor Gert Cauwenberghs from the Department of Bioengineering at the UC San Diego Jacobs School of Engineering. Cauwenberghs is also Co-Director of the UCSD Institute for Neural Computation.

The new sensors that Cognionics is developing are "wireless" in two different respects. First, the sensors record biopotential through clothing fabrics, and therefore do not touch the skin directly. "Today you have to put sticky patches on your chest to record this information. It's uncomfortable and messy," said Chi. Second, the information the sensors collect is sent to computers over wireless channels, rather than over wires.

"One of the goals of this wireless sensor project is to take the sensing technology out of the typical hospital setting and into the home environment, without constraining the mobility of the patient," said Cauwenberghs. "Also, our approach could allow you to monitor cardiac or brain activity during exercise, or to monitor the health of soldiers in the battlefield, so it can be transformative in that sense."

Various wireless sensor prototypes for recording biopotential have been around since at least the 1960s, but according to Chi, "no one has gotten it past a lab prototype… you don't see them out in the marketplace."

Chi cited problems with cost, reliability, and difficulty recording clinically relevant

Continued on page 10

Seminars and Upcoming Events and Announcements

INC Chalk Talk Series

Bimonthly meetings featuring labs at INC and other groups on campus with informal presentation of late-breaking and new research directions.

- 3/25/10 -- Yijun Wang, Yu-Te Wang, and Tzyy-Ping Jung, "Wireless EEG BCI"
- 4/1/10 -- Gabriel Silva, "ERG and electrophysiology of the retina"
- 4/15/10 -- Thorsten Zander, "Brain-computer interaction"
- 4/29/10 -- Joe Snider, Dongpyo Lee, Deborah Harrington, and Howard Poizner, "Virtual grasping in Alzheimer's disease"
- 5/13/10 -- Steve Furber, "Building brains"
- 5/27/10 -- Darren Schreiber, "This is your brains on politics"
- 6/10/10 -- Ralph J. Greenspan, "From sleep to consciousness in Drosophila"

INC Seminars and Joint INC/IEM Neuroengineering Seminars

- 3/10/10 -- Andrey Nikolaev, "Dynamics of EEG phase synchrony in the resting and working brain: quasi-stable intervals"
- 3/10/10 -- Gaute T. Einevoll, "What can we learn from multielectrode recordings of extracellular potentials in the brain?"
- 6/14/10 -- Don Robin, "Mapping processing time between cortical regions using single pulse transcranial magnetic stimulation"
- 6/18/10 -- Pietro Mazzoni, "The Basal Ganglia and Implicit Choices in Motor Control"
- 7/12/10 -- Elizabeth B. Torres, "Funneling attention in automated behavior"

Annual Spring Retreat -- Save the date! -- 5/1/10

UCSD Entrepreneur Challenge (continued)

A wireless sensor prototype (front sensor) and a wired, older prototype (back sensor). More photos on the Jacobs School blog.

electrical signals as causes of the roadblocks, particularly because wireless sensors are more complex than the wired versions.

"There are other companies that are doing wireless sensors, but Mike's solution offers one that eliminates not only the wires for transmitting the data, but also the wires between electrodes that are conventionally needed to establish a voltage signal with a reference and ground," explained Cauwenberghs.

Full article available at:

http://www.jacobsschool.ucsd.edu/news/news_releases/release.sfe?id=955

Congratulations! Awards, Grants, and Honors

Terrence Sejnowski

- Elected to National Academy of Sciences

Schwartz Center for Computational Neuroscience

- Awarded leading role in $25M ARL project

Poizner Lab

- Awarded ONR MURI grant

Integrated Systems Neurobiology, Cauwenberghs Lab

- Awarded DARPA Neovision2 grant with Evolved Machines, Inc. (lead), UC Berkeley, MIT, Stanford, and nVidia