UC San Diego
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UC San Diego in International Collaboration to Develop Wireless Implantable 'Neurograins'

Engineering faculty to receive nearly $4 million for subcontract on DARPA project

UC San Diego faculty on the neurograin subcontract include (l-r): PI Ramesh Rao, and co-PIs Patrick Mercier, Peter Asbeck (all ECE), Gert Cauwenberghs (Bioengineering), and CSE faculty-affiliate Terry Sejnowski (Salk Institute and the UC San Diego Institute for Neural Computation).

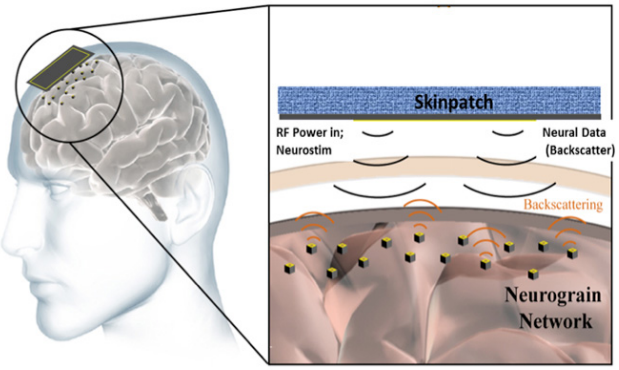
Five professors in the Jacobs School of Engineering at the University of California San Diego are part of an international collaboration led by Brown University and including the Salk Institute, Stanford University, UC Berkeley, Massachusetts General Hospital, Qualcomm Inc. and two international partners to develop a wireless neural prosthetic system that could record and stimulate neural activity with unprecedented detail and precision. The overall project is funded by the Defense Advanced Research Projects Agency (DARPA) through its new Neural Engineering System Design (NESD) program.

The project aims to create a "cortical intranet" of tens of thousands – and up to 100,000— wireless micro-devices that can be safely implanted on or into the cerebral cortex (the outer layer of the brain). Dubbed 'neurograins' because each is about the size of a grain of table salt, the implants will operate independently, interfacing with the brain at the level of the individual neuron. The activity of the devices will be coordinated wirelessly by a central communications hub in the form of a thin electronic patch worn on the skin or implanted beneath it.

Eventually, researchers hope the wireless neural prosthetics will lead to new medical therapies for people who have lost sensory function due to injury or illness.

"The understanding of the brain we can get from such a system will hopefully lead to new therapeutic strategies involving neural stimulation of the brain, which we can implement with this new neurotechnology," said principal investigator Arto Nurmikko, the L. Herbert Ballou

University Professor of Engineering at Brown University. Nurmikko's team will focus on decoding neural processing of speech, notably the tone and vocalization aspects of auditory perception.



The new system will use microdevices to both "read out" and "write in" neural information. [Image courtesy of Brown University]

The grant to Brown University totals up to $19 million. Of that, nearly $4 million will go to UC San Diego under a subcontract with Qualcomm Institute director Ramesh Rao as principal investigator. "UC San Diego has a major role to play in creating what is essentially a micro wireless communications network for the brain to transmit and receive signals between individual neurons and the digital world," said Rao, who is also a professor in the Electrical and Computer Engineering (ECE) department. "This project leverages our university's cutting-edge leadership in wireless communications, circuit design and neuroscience, and we have long-standing partnerships with other research teams on the DARPA project."

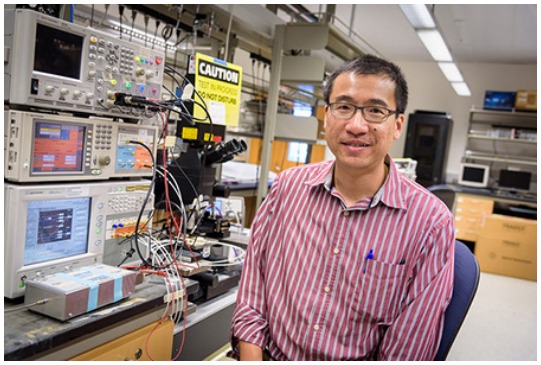
Engineering faculty undertaking the research at UC San Diego will include Rao's fellow ECE professors Peter Asbeck and Patrick Mercier, as well as Institute for Neural Computation co-directors Terry Sejnowski and Gert Cauwenberghs, (Computational neuroscientist Sejnowski is also a professor at the Salk Institute and faculty-affiliate in Computer Science and Engineering, while Cauwenberghs is a professor of Bioengineering in the Jacobs School.)

Researchers from the Jacobs School will focus on designing analog and wireless electronics for the 'neurograin' microchips that are a critical part of the overall system under development.

"The cortical intranet linking neurograins in the brain will be designed to have both 'read-out' and 'write-in' capabilities," said ECE professor Patrick Mercier. "It will be able to record neural activity, helping to deepen scientists' understanding of how the brain processes stimuli from the outside world."

The network will also have the capability to stimulate neural activity through tiny electrical pulses – a function that researchers hope to eventually use in human clinical research aimed at restoring brain function lost to injury or disease.

Other key personnel on the project include UC San Diego alumnus Vincent Leung (Ph.D. '12), who runs the Circuits Labs in the institute, where much of the technology on the DARPA project will be tested. (Leung's Ph.D. advisor at UC San Diego was then-ECE professor Larry Larson, who is now at Brown University and is a co-PI on the main DARPA grant.)



Qualcomm Institute staff researcher and ECE alumnus Vincent Leung (Ph.D. '04), who manages QI's Circuits Labs, will support the overall UC San Diego effort as well as researchers from Brown University (including his former Ph.D. advisor Larry Larson) on the DARPA project.

The UC San Diego researchers will participate in three of the DARPA project's five major tasks. One is the neurograin layer (involving microfabrication of the sub-millimeter and implantable microsensors). Second is the telecom layer (i.e., the head-mounted 'skinpatch' with ultralow-power RF electronics and a subcutaneous hub optimized for network communication). "The skinpatch becomes the *de facto* wireless base station for transmitting and receiving signals," explained Mercier. "In doing so, it powers the neurograins and serves as the hub for relaying data to and from an external command center that transcodes and processes neural and digital signals."

The third major task involves the decoding/encoding layer and its implementation as a body-wearable neural signal processor with decoding/encoding algorithms and computational hardware.

The remaining two major tasks of the project will be spread out among researchers at Brown University and subcontractors affiliated with the other collaborating teams, including two international partners: IMEC (a Belgian microtechnology institute), and the Wyss Center for Bio and Neuroengineering in Geneva, Switzerland.

DARPA's NESD program aims to develop new devices that will be able to "provide advanced signal resolution and data-transfer bandwidth between the brain and electronics."

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