Neuroscience Meets AI

NIH Grant Supports Development of a Smart Bionic Eye

UCSB's interdisciplinary Bionic Vision Lab is on a mission. Their goal? To unravel the science behind the bionic technologies that could one day restore useful vision to people living with incurable blindness.

"One idea is to put a chip in the eye or the brain and stimulate the surviving neurons with electrical current," explains Assistant Professor **Michael Beyeler**, the lab's principal investigator. "If you do that, the other neurons can't tell whether they were activated artificially by an electrode or naturally."

Matt Perko, UC Santa Barbara

Michael Beyeler

Although the field is in its infancy, such prosthetic devices already exist. They are known as "bionic eyes." Beyeler's interest is in taking them to the next level and developing *smart* bionic eyes.

In their current state, what the users of these devices see are basically flashes of light. "That's what people describe," Beyeler says. "It's like looking at fireworks. Sometimes the flashes combine to form something more complex, and sometimes they don't. It's really a matter of understanding the neuroscience behind it—and then tapping into that as computer scientists and engineers and leading the brain into thinking it saw something."

So the lab is focusing on the fundamentals of neuroscience, and then incorporating AI to optimize the way these devices are stimulated.

It's a challenging project, made more so because any two people wearing the same device don't see the same things. The Bionic Vision Lab's team of PhD students, MS students, and undergrads is bringing together their expertise in computer science and psychological and brain sciences to explore and find solutions to these problems.

"Some of our great CS students have built deep learning models to predict—if you want to produce a certain image in the mind of the patient—how you should stim-

ulate the device. And you can personalize that strategy using feedback, like human-in-the-loop algorithms."

For his efforts, Beyeler was recently awarded the prestigious National Institutes of Health Director's New Innovator Award, providing a five-year, $1.5 million grant for his project "Towards a Smart Bionic Eye: AI-Powered Artificial Vision for the Treatment of Incurable Blindness." This is only the fifth time that this highly competitive grant has gone to UCSB.

"The idea of the grant is that we can preprocess the images in a better way," he explains. "We can use computer vision, we can use machine learning, to extract what is important and then visualize that in an intuitive way."

As an example, he talks about looking for lost keys. With current devices, you're just looking through a mess of flashes of light.

"What we do is we segment the image. We would figure out, okay, here's a table, here's a different object on top of it, and detect in this input image where the keys are, and then highlight that for the user."

He envisions a system that could speak with you, or you could give it audio commands. Based on your context or task, the demands change. If you're in a room looking for keys, you could say "Hey bionic eye, where are my keys?" and the device would highlight them visually when you look around the room. But there's a different set of circumstances when you're navigating outside, for example, and you have to cross the street. In that case, the device might highlight nearby obstacles or approaching cars.

"The idea of this grant is that we preprocess and segment the image. We can use computer vision, we can use machine learning, to extract what is important, and then visualize that in an intuitive way."

This is a big vision for a young technology, and much of the groundwork is still being laid. A number of manufacturers are working to develop devices, but none are currently close to commercialization.

"That's one of our challenges as an academic group. We constantly have to think on our feet, finding new partners as the industry changes."

Some of the Bionic Vision team recently traveled to Spain to visit one such collaborator, who has a cortical device that bypasses the eye and goes directly into the visual cortex.

"We were able to test our theories and algorithms on those patients and collect data, then come home and analyze it."

That's just one more small but important step on a long road toward completing an ambitious vision.

New Faculty
Shiyu Chang

Before joining UCSB as an assistant professor, **Dr. Shiyu Chang** completed both his undergraduate and PhD studies at the University of Illinois at Urbana-Champaign, followed by several years working in research labs. That includes time at the MIT-IBM Watson AI Lab, where he collaborated with faculty and students on advanced machine learning and natural language processing.

Santa Barbara has been a fantastic place to live and work ... I feel fortunate to be part of this family.

Dr. Chang continues this work at UCSB with research into enhancing the trustworthiness of large language models, addressing issues such as bias, uncertainty, robustness, and hallucinations. One of his highlights here so far, he says, has been teaching an undergraduate deep learning course.

"It has been incredibly rewarding to see students from various backgrounds come together, engage with the material, and bring their unique perspectives to class … Watching their growth and enthusiasm, and seeing them apply these concepts to their fields of study, has been truly rewarding."