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POPULAR SCIENCE

‘BRILLIANT 10’

Maryam Shanechi Decodes the Brain to Unlock Its Potential

BUILDING THE NEXT BRAIN-MACHINE INTERFACES

By Veronique Greenwood and Cassandra Willyard

Illustrations by Alexander Wells

Maryam Shanechi used to study wireless communications systems. Now she investigates a far more complex network: the billions of neurons that make up the human brain. Shanechi, a neuroengineer at the University of Southern California, is trying to crack the neural code to develop better brain-machine interfaces.

Existing devices simply translate the brain’s electrical signals into movement, enabling paralyzed people to move a computer cursor or a robotic arm. Shanechi applies control theory. In other words, she decodes neural activity from many parts of the brain to provide more-precise control. Next, she wants to translate those algorithms into signals the spinal cord can understand so paralyzed patients can move their own limbs.

Her team is already making headway. Last year, they processed the neural activity of a monkey and translated it into spinal stimulation that moved a second, sedated monkey’s hand. The system doesn’t work perfectly yet, but Shanechi has recently developed a more accurate model that tracks the brain’s activity by the millisecond. She’s also working on algorithms to help the brain self-regulate, providing stimulation that alleviates depression or post-traumatic stress disorder. Decoding mood is even more difficult than deciphering movement, but Shanechi says, “That’s what makes it interesting.”

Bhaskar Krishnamachari Networks Cars for Safer Roads

PREVENTING THE NEXT 194-CAR PILEUP

When Bhaskar Krishnamachari moved to Los Angeles, he hadn’t spent much time thinking about cars. But one gloomy day, he caught a news report about a 194-car pileup. The fog hung so thick, drivers couldn’t see the impending accident until it was too late. That disaster could have been avoided, Krishnamachari thought, if only cars could talk to one another.

A network engineer at the University of Southern California in Los Angeles, Krishnamachari envisions a future in which cars are bilingual—able to converse with cell towers, as some can today, but also with other vehicles through digital short-range radios. A car slamming on its brakes could send a warning to any vehicle within half a block in milliseconds. Such a system could also be used to disseminate data that needs to reach many vehicles, such as software updates. Once a subset of cars downloads it through the cellular network, the data would spread to others nearby.

Krishnamachari has been collaborating with General Motors since 2007 to develop vehicle-to-vehicle communication, and he has already tested it in a handful of cars. Last year, the team used GPS data from more than 600 taxis in Beijing to simulate how the system might work in a larger fleet. The U.S. Department of Transportation also considers vehicle-to-vehicle communication the future: It recently announced plans to require such devices in new cars. The technology could help pave the way for self-driving cars, or even teams of robots doing remote exploration or disaster response. Krishnamachari is designing a system that’s flexible. “When you build a network,” he says, “you don’t want to build it for specific applications.”

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Engineering professors among the *Popular Science* 'Brilliant 10'

By Natalia Velez

USC Viterbi School of Engineering Professors Maryam Shanechi and Bhaskar Krishnamachari. *Photo by Gus Ruelas*

Bhaskar Krishnamachari and Maryam Shanechi of the USC Viterbi School of Engineering are included among the *Popular Science* "Brilliant 10" for their contributions to the areas of wireless networks and brain-machine interfaces, respectively.

"At *Popular Science*, we believe many of the world's most challenging problems can be solved through brilliant science and engineering," said Executive Editor Jennifer Bogo. "Our 10 honorees are at the bleeding edge of their fields and are already well on their way to making the world a better, safer, smarter place."

This is not the first time that USC Viterbi faculty members have appeared on the list. In 2013, Professor Andrea Armani of the Mork Family Department of Chemical Engineering and Material Science was honored for her research in materials, optics, photonics and biodetection.

Wireless information

Krishnamachari is developing techniques to reduce the cost of wirelessly sending information to cars and other vehicles. His work is highly relevant since nearly all car manufacturers currently offer connectivity to their cars for various information services, such as General Motors' On Star and Ford's Sync, and new cars such as Tesla's Model S, which can be upgraded using wireless software updates.

His research focuses on a completely new paradigm of vehicle-to-vehicle communications in which information is exchanged between cars. The more cars are on the network, the quicker information will transfer. This is the exact opposite of cellular networks, where information transfers become slower as the number of users rises.

"While I feel thrilled and honored, I credit this recognition to the amazing Ph.D. students I have the privilege to work with in the Autonomous Networks Research Group at USC Viterbi," said Krishnamachari, who in 2011 was named one of "the world's top 35 innovators under 35" by *Technology Review* at the Massachusetts Institute of Technology.

Neurological disorders

Shanechi, director of the Neural Systems Engineering and Information Processing Laboratory and holder of the Viterbi Early Career Chair in Electrical Engineering, conducts research that straddles the line between engineering and neuroscience. She, too, was named to the Technology Review list of top global innovators in 2014. Shanechi works at the interface of control theory, statistical signal processing and neuroscience to develop brain-machine interfaces (BMI) that address various neurological injuries or disorders such as paralysis or depression.

While prior BMIs for restoration of movement have largely controlled external prosthetics, she has developed the first BMI that allows paralyzed subjects to move a native arm in two dimensions using their thoughts alone. She has also developed BMIs that allow subjects to control a prosthetic significantly faster than the state-of-the-art systems. This work earned Shanechi the NSF Career Award in February, which Krishnamachari received in 2004.

"My lab focuses on developing brain-machine interfaces that address various neurological disorders," Shanechi said. "These have the potential, for example, to one day restore movement to paralyzed patients or to help patients with depression."

Shanechi is also developing the next generation of BMI systems that offer the possibility of controlling neuropsychiatric disorders, such as depression and PTSD, as part of a DARPA program and the Obama BRAIN initiative. Her system would electrically stimulate the brain to revolutionize treatments for these disorders, which are currently approached with psychotherapy and medication.

"I am thrilled to be included in this year's list," Shanechi said. "It is a really exciting time for engineers to help understand the brain's mysteries and develop neurotechnology to treat the brain's disorders."