Seeking Problem Solvers

Shaping the Next Generation of Doctoral Students

There is a transformation taking place in robotics. As machines become more interactive and integrated into our lives, people from diverse backgrounds are flocking to the field to tackle new challenges. Bhoram Lee and Sonia Roberts, two doctoral candidates in Electrical and Systems Engineering (ESE), are both conducting research that will shape the next generation of autonomous machines, whether it be self-driving cars, delivery drones or Martian rovers. But their interests, backgrounds and skillsets could not be more different.

Lee, a former researcher at Samsung, is fascinated by how robots perceive the world. Roberts, a cognitive scientist-turned-engineer, is interested in how machines move about in it. At Penn, each of these women has found a niche where her abilities can flourish.

EYES LIKE A HUMAN'S

Computers have always been a big part of life for Lee, who grew up in South Korea with an electrical engineer and programmer for a father. After graduating from Seoul National University with bachelor's and master's degrees in mechanical and aerospace engineering, Lee took a job at Samsung, where she spent five years developing algorithms for mobile user interfaces. But an interest in pushing the boundaries of artificial intelligence eventually drew Lee back toward academia. When she learned that Daniel Lee, UPS Foundation Professor in ESE, was producing novel research at the interface of neuroscience and machine learning, she decided to apply to Penn.

"Bhoram came from an unusual background, being a researcher at Samsung," recalls Daniel Lee, also the director of the General Robotics, Automation, Sensing and Perception (GRASP) Laboratory. "She was on a number of patents, which you don't often see. I could tell she would be a very mature Ph.D. student."
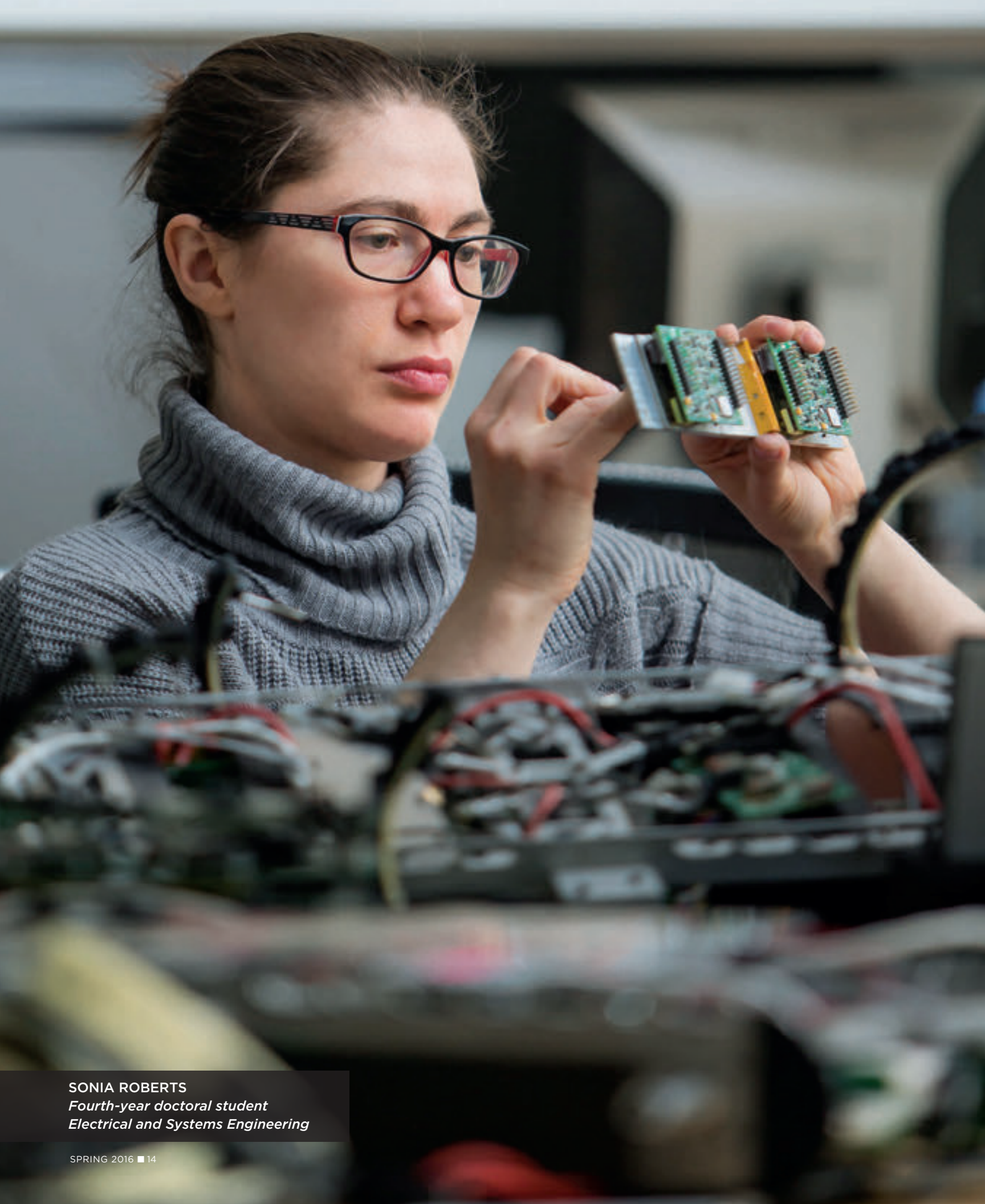
BHORAM LEE'S THESIS RESEARCH USES MACHINE-LEARNING TECHNIQUES TO HELP ROBOTS IDENTIFY OBJECTS IN CHANGING ENVIRONMENTS.

Both Lee and her husband took positions at Penn, and in 2013, they moved to the United States with their two daughters. In her third year now, Lee has finished her coursework and is busy with her thesis research, which involves using machine-learning techniques to help robots identify objects in changing environments. "Robots need to interact a lot with the real world," she remarks. "But if lighting conditions suddenly change, an object can look very different." In order to teach robots to keep their eye on the ball, Lee is writing algorithms that use visual information from the recent past to predict the immediate future.

"Rather than attempting to process every image pixel, Bhoram's algorithms allow a computer to focus on mathematical relationships that prioritize important features of images in video streams," says Stephen McGill, a fellow ESE doctoral

BHORAM LEE
Third-year doctoral student
Electrical and Systems Engineering

student who collaborated with Lee at the Defense Advanced Research Projects Agency (DARPA) Robotics Challenge last year. "Her work is proven on automobiles and humanoid robots."

DESERT WANDERERS

Roberts also took an unusual path into robotics. As a cognitive science major at Vassar College, she became fascinated with the different ways in which intelligence is expressed across the tree of life—and not just in the brain. For instance, as a cockroach scuttles across the ground, its legs react deftly to changing terrain, much faster than would be possible if they were relying on signals from the animal's motor cortex. "I became interested in whole-body approaches to intelligence, and the easiest way to experiment on that is to build an organism," she notes. "That got me into robotics."

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Her interest in replicating animal behavior in machines is what led Roberts to join the laboratory of Daniel Koditschek, Alfred Fitler Moore Professor in ESE, who also collaborates closely with senior researchers in biology and neuromechanics. "Sonia is a very bold and original thinker," Koditschek says. "She's trying to discern the difficult and elusive problem of teasing apart form and function, and in turn design that intelligence in artificial bodies. And she's doing it with great forethought and planning."

Roberts is now in her fourth year at Penn, has finished her coursework, and is collaborating with researchers at the U.S. Department of Agriculture to design robots that are more adept at walking in sand. In geology, ecology and climate change research, there's a great need for machines that can move about independently in deserts, collecting data without getting stuck.

"Sonia is a great collaborator, and she brings with her a wealth of information from a field that most of us know very little about," says Gavin Kenneally, a fellow doctoral student in Koditschek's lab who collaborates closely with Roberts. "She is always happy to discuss our research and never at a loss for an opinion."

ALL-INCLUSIVE

Electrical engineering is working to overcome one of the widest gender gaps of any STEM field, where women comprise less than 20 percent of all doctoral graduates nationwide. As the community becomes more inclusive and diverse, stereotypes about the "typical" electrical engineer are beginning to fade. "What's happening is the field of robotics is becoming less siloed and more interdisciplinary," notes Daniel Lee. "This is a great time for women in engineering."

Koditschek agrees. "We need engineers from all backgrounds in order to solve the problems we are looking to solve. We need more people interested in animal physiology, more people interested in cognitive science and in philosophy. When you find the creativity, power, and nettle of a prospective student like Sonia, you immediately want to get her involved." ▼

By Madeleine Stone