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How Do Java Mutation Tools Differ?

Turing Lecture: Jack J. Dongarra

Q&A with Timnit Gebru and Alex Hanna

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communication, and the use of light, sounds, air pressure, and chemicals that could contribute to greater collective intelligence.

At the center of this concept is a different way of thinking about computing and communication, Sycara explains. Traditionally, computing and robotics models revolve around a central coordinator or "brain" that runs a system. However, in order for a swarm to function effectively—and without direct communication and control—intelligence must be distributed and decentralized, much like a colony of ants or a hive of bees. This requires local interaction laws and complex algorithms that can analyze and understand numerous situations and scenarios, including the loss of some units of the group.

The good news, Sycara says, is that nature and computer algorithms align reasonably well. "Currently swarm algorithms are based on control theory, but could be further enhanced by AI-powered algorithms. These swarms could be designed with decentralized algorithms that enable the individuals of a robot swarm to communicate with each other, adapt to an uncertain environment, and build consensus on situational awareness through local interaction laws," she says. This decentralized model also offers the advantage of making it harder to trick or manipulate a robot swarm into doing something it is not designed to do.

In a swarm model, Petersen says, it is imperative to imbed pieces of intelligence on each device, but also to create ways for individual robots to share knowledge both directly and through mechanical and physical interactions. This means individual components might carry part of the code required, and in some cases they might carry duplicate code. Devices could share and swap information as needed.

"You can program a lot of the intelligence onto the morphology of the robot, similar to the concept of form and function in nature but using communication to handle other parts of the task, including updating and changing behavior dynamically," Petersen says.

The robots in a swarm "can impact and affect each other and create an emergent complexity that exceeds the sum of the individual parts."

Minding the Group

Collaborative robotics is beginning to take shape. For example, researchers at Harvard University's Wyss Institute have developed an autonomous robot swarm that can replicate the motions of fish. It accommodates individual decision-making, but also supports collective behaviors that benefit the entire school/swarm. These so-called *Bluebots*, part of a *Blueswarm* of 1,000 "fish," are each equipped with two cameras and three LED lights. Tiny onboard cameras detect the LEDs from neighboring Bluebots and calculate their distance, direction, and heading with an onboard algorithm.[a]

Through the use of implicit rules and three-dimensional (3D) visual perception, researchers were able to build a swarm system that has a high degree of autonomy and flexibility underwater, where GPS and Wi-Fi generally are not accessible.

Another group of researchers have developed tiny 3D-printed circular micro-robots, each approximately the width of an averaage human hair. The devices, made from polymer material coated in cobalt and surrounded by wire coils that function as tiny magnets, make it possible to tune and reconfigure the group on demand within an air-water interface.[b] The micro-robots were created by Wendong Wang, an associate professor at the University of Michigan-Shanghai Jiao Tong University Joint Institute in Shanghai, China, who collaborated with Petersen, Ceron, Gardi, and Max Planck Institute professor Metin Sitti.

The project further demonstrated the viability of swarm systems. The researchers made 120 micro-disks form

a https://bit.ly/3S9Yslf
b https://go.nature.com/3SgnaQE

ACM Member News

PROMOTING ACCESSIBILITY THROUGH ABILITY-BASED DESIGN

"When I was 10 years old, my parents gave me an IBM PCjr," recalls Jacob O. Wobbrock, professor of information at The Information School and, by courtesy, at the Paul G. Allen School of Computer Science & Engineering at the University of Washington.

Wobbrock says he has been hooked on computing ever since.

He went on to earn his undergraduate degree in symbolic systems (which integrates knowledge from fields including computer science, linguistics, mathematics, philosophy, psychology, and statistics), and a master's degree in computer science, both from Stanford University. He then earned a doctorate in human-computer interaction from Carnegie Mellon University.

Wobbrock joined the faculty of the University of Washington in 2006, and still teaches there today.

His research focuses on human-computer interaction, with his two main areas of concentration being mobile computing and accessible computing. "I integrate methods from computer science, experimental psychology, statistics, and interaction design into my work," Wobbrock says.

Currently, Wobbrock is interested is in the failure of many mobile user interfaces and mobile devices to be sufficiently accessible.

"I've created a design approach for accessibility called ability-based design," Wobbrock says, explaining that instead of users having to conform to the demands and assumptions of a technology, the system conforms to the needs of the users.

In the future, Wobbrock aims to provide tools to developers to make technology (especially mobile apps) more ability-aware, so users ultimately have more-accessible experiences.

—John Delaney