Automation in life sciences: How can science help?

Research Group Neuromorphic Computing

Prof. Dr. Yulia Sandamirskaya
Head of Research Group Neuromorphic Computing,
yulia.sandamirskaya@zhaw.ch

Research Projects

Neuromorphic Technology for Embodied AI (DIZH Fellows 2024)

YuRo: Real-time 3D vision for robots (Founder Call project)

Project leader:
Prof. Dr. Yulia Sandamirskaya, Centre for Cognitive Computing in Life Sciences

Partner:
Intel and SynSense (neuromorphic hardware), INIVation and Prophesee (retina-inspired cameras), NEURA Robotics (cognitive robots), and WAIYS (use cases).

Funding:
DIZH

When you think about robots, you probably think either about heavy machines in large factories or about cute (or scary) characters created in Hollywood. Or maybe you think about Karel Capek's science fiction and the meaning of the Slavic word "robota" (meaning "work") – and wonder why there are still so many tedious, repetitive chores to do today, when AI seems to be booming. Well, the answer is that robots today perform poorly when they need to do work in unstructured, natural, and human-centred environments. ZHAW's ICLS started a research and innovation journey to build bio-inspired technology for autonomous systems (robots) in life science industries, to work side by side with humans.

What is the main bottleneck holding up robotic autonomation in life sciences – agriculture, healthcare, environment protection? Perception has always been the key challenge. Artificial intelligence has recently brought incredible breakthroughs in building perception systems – image recognition, segmentation, and depth perception can all be addressed by training large deep neural networks with enough examples of the task solved well. Although it has recently been extraordinarily successful in image processing and text generation, the deep neural network-based (DNN) approach has serious limitations when used on robots:

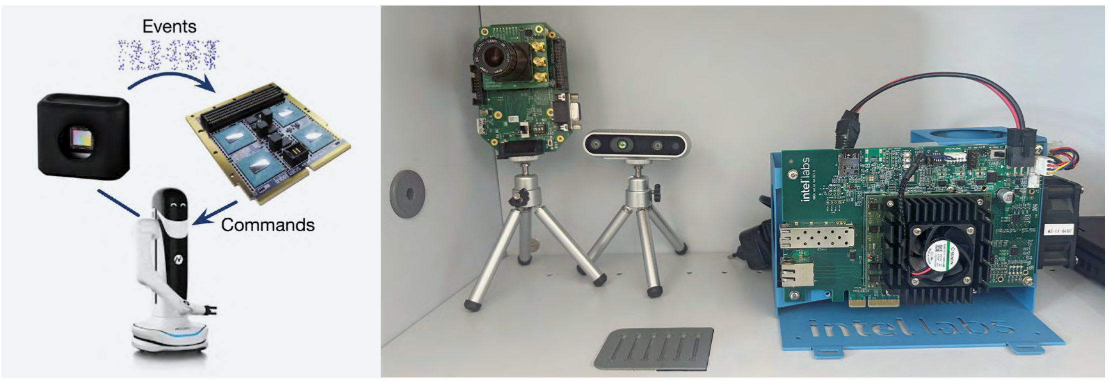
First, large DNNs are an algorithm requiring a lot of computation. Robots have limited on-board power and limited time to issue the next control command – just a few milliseconds. Robots require faster visual feedback during movement to replan a movement, e.g., to avoid a collision or to grasp a moving object.

Second, large DNNs need a long time (and even more computing power) to learn. And robotics is a field where things change – lighting conditions, viewpoints, weight, and the shape of the objects being grasped. There are just too many possible conditions to consider them all in advance in a training dataset. Robots need an ability to learn when already deployed. This task is very hard with DNNs: their many layers are deeply entangled, and any learning example influences the weights only slightly. You require a lot of examples to make the network change its behaviour. This is very different from humans, who often learn about a new object from a single experience.

Hardware inspired by biological neural systems

In the Neuromorphic computing group at the ICLS, we work with computing and sensing technology that is inspired by biological neural systems – not only the algorithms, but also the hardware. The figure shows a camera – a dynamic vision sensor – that works like a human retina. It doesn't sample images at a fixed frame rate. Instead, each pixel – like a cell in the retina – detects luminance change and sends a small data package with its coordinates to the computer. The arrival of such an "event" signals that a change has been detected. The neuromorphic computing chip, shown next to the camera, can process exactly such "event-based" information. The chip runs a spiking neural network. Neurons in this network also send out events or spikes if they detect relevant signals or features. Together, the camera and the chip allow us to develop perception systems that can detect objects, track them, and estimate their position in real time. Moreover, these systems can learn quickly using biologically inspired "Hebbian" learning.

The field of neuromorphic computing studies computation in biological and artificial neural systems. In our group, we specifically target systems to control autonomous robots. With such capability, the robots can be safer and more efficient in dynamic environments and spaces shared with people. ■



This dynamic vision sensor works like a human retina. Each pixel detects luminance change and sends a small data package to the computer. The neuromorphic computing chip, shown next to the camera, can process exactly such "event-based" information. The left-hand picture provides a schematic representation, while the right-hand picture is a photo of the cameras and the chip in the current prototype version.