Using artificial intelligence to enhance complex systems

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EPFL researchers have invented a way of automatically working out what data needs to be put into a complex system—such as a fiber optic network—in order to get the desired result. Their solution could prove especially useful in robotics, medicine and image projection.

In any system, you need some kind of input and output, with an action taking place in between. But when that action is particularly complex or requires large amounts of synchronized data, how do you know what input is needed to get the right output? Researchers from the Laboratory of Applied Photonics Devices (LAPD) and Optics Laboratory (LO) at EPFL have found a solution. They've invented an algorithm that can determine what data needs to be fed into a fiber optic network in order to get the desired result at the other end. Their research has just been published in the journal *Nature Machine Intelligence*.

The researchers developed an image projection system to demonstrate their technique. In a maze-like network of lasers, light beams go from one magnifying glass to the next and from one fiber to the next, taking coded information with them. At the other end, the information is decoded on a little screen, where a series of green images appear—a galloping horse, a wandering person and a strange ghost.

"Fiber optics are complex systems," explains Babak Rahmani, a Ph.D. student in the LAPD lab. "Without our algorithm, the information needed to create each image would have to be recalculated each time. But with our algorithm, the system learns how to do that automatically."

The researchers' funny animations are simply an illustration of their solution's many potential applications in a number of fields. "It could be used to help a robotic arm learn a specific gesture and how to control it," says Christophe Moser, who runs the LAPD lab. In medicine, it could enhance endoscopic techniques that use lasers to create a certain effect on specific parts of the body.

And more broadly speaking, the algorithm could make it easier to project light or trigger an effect or action remotely, or to create 3-D images and holograms.

Two is better than one

The invention draws on the principle of artificial neural networks. "These networks are computer systems inspired by biological neural networks and the human brain," says Demetri Psaltis, who runs the LO lab and is an expert in this technology. They're the basis of artificial intelligence and allow the systems they're used in to engage in machine learning.

The neural-network technique itself is not new. What makes the EPFL researchers' work original is that it involves two systems that work together. "It's a bit like learning to play tennis," says Psaltis. "First, you just learn how to hit the ball. Once you've got the hang of that, you move on to more difficult shots, like the backhand, the overhead and the volley. Our algorithm works the same way."

More information: Babak Rahmani et al. Actor neural networks for the robust control of partially measured nonlinear systems showcased for image propagation through diffuse media, *Nature Machine Intelligence* (2020). DOI: 10.1038/s42256-020-0199-9

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