New fiber optic sensors transmit data up to 100 times faster

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Simon Zaslawski, Zhisheng Yan and Prof. Luc Thévenaz. Credit: EPFL / Alain Herzog

Fiber optic sensors—used in critical applications like detecting fires in tunnels, pinpointing leaks in pipelines and predicting landslides—are about to get even faster and more accurate.

EPFL engineers have developed an advanced encoding and decoding system that allows fiber optic sensors to send data up to 100 times faster and over a wider area. "Unlike conventional sensors that take measurements at a given point, like thermometers, fiber optic sensors record data all along a fiber," says Luc Thévenaz, a professor at EPFL's School of Engineering and head of the Group for Fibre Optics (GFO). "But the technology has barely improved over the past few years."

Used widely in safety applications

Fiber optic sensors are commonly used in hazard detection systems, such as to spot cracks in pipelines, identify deformations in civil engineering structures and detect potential landslides on mountain slopes. The sensors can take temperature readings everywhere a fiber is placed, thereby generating a continuous heat diagram of a given site—even if the site stretches for dozens of kilometers. That provides crucial insight into possible accidents before they happen.

Improving signal quality

Working in association with the Beijing University of Posts and Telecommunications, two GFO engineers—postdoc Zhisheng Yang and Ph.D. student Simon Zaslawski—developed a new system for encoding and decoding data sent along the fibers. With their method, sensors can receive higher-energy signals and decode them faster, resulting in measurements taken more rapidly and over a larger area. Their research has just been published in *Nature Communications*.

The engineers describe their system as working like an echo. If you shout a single word, you hear that word back. But if you sing out a song, what you hear back is a blend of sounds that are hard to distinguish. You would need a 'key' to decipher the sounds and make them intelligible. Fiber optic sensors function in a similar manner, except that an instrument sends out light pulses—rather than sounds—along a fiber. Signals bounce back up the fiber and a device decodes them, turning the signals into usable data.

To make the sensors more efficient, Yang and Zaslawski grouped the light pulses into sequences so that the signals bounce back with greater intensity. However, that didn't solve the "echo" problem—that is, finding a key to make the signals readable. So they developed a method for encoding the data sent along a fiber; their method employs special genetic optimization algorithms to cope with imperfections. "Other systems are either limited in scope or expensive," says Thévenaz. "But with ours, you just have to add a software program to your existing equipment. No need to adapt your sensors or use complex devices."

More information: Xizi Sun et al. Genetic-optimised aperiodic code for distributed optical fibre sensors, *Nature Communications* (2020). DOI: 10.1038/s41467-020-19201-1

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