Single-end hybrid Rayleigh Brillouin and Raman distributed fiber-optic sensing system

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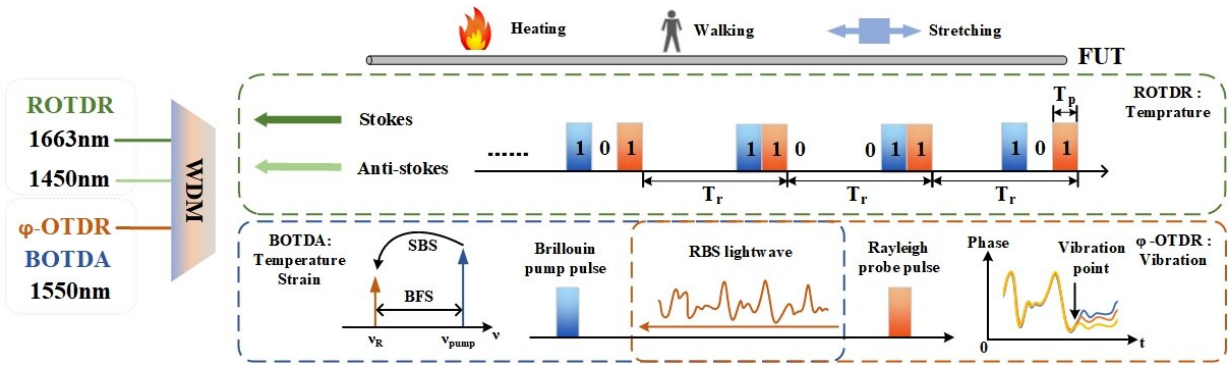

Working principle of the hybrid DFOS system. Credit: Linjing Huang, Xinyu Fan, Haijun He, Lianshan Yan, Zuyuan He

The real-time monitoring of facilities, particularly large facilities (such as rail transit systems, large bridges, and buildings), can provide information regarding their surrounding environment and allow their health conditions to be assessed, which is essential for establishing the current concept of smart cities based on the Internet of Things.

As a precise real-time monitoring technique, distributed fiber-optic sensing (DFOS) systems, which require long-distance simultaneous measurements along a sensing fiber, are in high demand for various industrial applications. However, most DFOS systems can only measure a single kind of parameter, which limits the use in applications.

Additionally, combining different DFOS systems is complex and costly.

In a new paper published in *Light: Advanced Manufacturing*, a team of scientists, led by Professor Xinyu Fan from Shanghai Jiao Tong University, China, proposed a simplified hybrid DFOS system for simultaneously measuring multi-parameters along the sensing fiber. They used a normal single-mode fiber as a sensor to obtain the temperature, strain and vibration information of the optical fiber with the length of several kilometers.

They integrated three schemes using different backscattered lightwave and simplified the hybrid systems. The proposed hybrid system requires only one light source, two receiving ends and a single access of the fiber for launching lightwave, which highly reduces the complexity of application. As such, the simplified hybrid system can be used in real-time monitoring of large structure, automated control and perimeter security. The technique can be a powerful tool promoting the construction of smart cities.

Among different DFOS systems is a technique that uses Rayleigh backscattering known as phase-sensitive optical time-domain reflectometry (φ-OTDR), which is used to measure dynamic parameters such as vibration.

Brillouin optical time domain analysis (BOTDA) based on stimulated Brillouin scattering is used to measure temperature and static strains with high signal-to-noise ratio. Raman scattering can be used in Raman optical time-domain reflectometry (ROTDR) to measure the distributed temperature without being disturbed by strain as it is only temperature sensitive.

The hybrid DFOS system integrates the three different scattering schemes. Rayleigh scattering is used for vibration sensing and also acts

as the probe of Brillouin scattering process to realize temperature and strain measurement. Raman scattering is used to overcome the temperature-strain cross sensitivity. Pulse code modulation is employed to separate Raman scattering of two pulses with very close optical frequencies. In this way, a single-end simplified hybrid DFOS system works successfully for simultaneous multi-parameters measurement.

The hybrid system shows its ability of measuring temperature, strain and vibration along a 9-kilometer long single mode fiber, with a favorable measurement accuracy.

More information: Linjing Huang et al, Single-end hybrid Rayleigh Brillouin and Raman distributed fibre-optic sensing system, *Light: Advanced Manufacturing* (2023). DOI: 10.37188/lam.2023.016

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