National Aeronautics and
Space Administration

TECHNOLOGY SOLUTION

Sensors

Adaptive Spatial Resolution Enables Focused Fiber Optic Sensing

Innovation dynamically provides fast signal processing and precision measurement

This advanced fiber optic sensing innovation developed at NASA's Armstrong Flight Research Center offers a unique combination of high-resolution processing and flexibility. The algorithm was originally developed to enhance Armstrong's multi-patented Fiber Optic Sensing System (FOSS). With over 2,000 sensors per fiber, FOSS enables thousands of high-resolution measurements at once, including strain, shape, temperature, pressure, and more. The new adaptive spatial resolution innovation allows users to specify resolution and accuracy requirements. By making it possible to optimize data transmission bandwidth and adjust processing to minimize extraneous computations, this technology effectively provides the right resolution in the right place at the right time. This new capability opens up myriad new applications for fiber optic sensing systems, including in civil engineering, transportation, oil and gas, medical, aerospace, and many more industries.

BENEFITS

- Adaptive: Provides variable spatial resolution as needed along the length of an optical fiber
- Flexible: Allows for parallel processing of thousands of real-time measurements
- Automated: Increases resolution only where and when needed, reducing processing time and volume of data
- Fast: Optimizes processing time based on desired measurements and parameters

THE TECHNOLOGY

This technology can be applied to most optical frequency domain reflectometry (OFDR) fiber optic strain sensing systems. It is particularly well suited to Armstrong's FOSS technology, which uses efficient algorithms to determine from strain data in real time a variety of critical parameters, including twist and other structural shape deformations, temperature, pressure, liquid level, and operational loads.

How It Works

This technology enables smart-sensing techniques that adjust parameters as needed in real time so that only the necessary amount of data is acquired—no more, no less.

Traditional signal processing in fiber optic strain sensing systems is based on fast Fourier transform (FFT), which has two key limitations. First, FFT requires having analysis sections that are equal in length along the whole fiber. Second, if high resolution is required along one portion of the fiber, FFT processes the whole fiber at that resolution. Armstrong's adaptive spatial resolution innovation makes it possible to efficiently break up the length of the fiber into analysis sections that vary in length. It also allows the user to measure data from only a portion of the fiber. If high resolution is required along one section of fiber, only that portion is processed at high resolution, and the rest of the fiber can be processed at the lower resolution.

Why It Is Better

To quantify this innovation's advantages, this new adaptive method requires only a small fraction of the calculations needed to provide additional resolution compared to FFT (i.e., thousands versus millions of additional calculations). This innovation provides faster signal processing and precision measurement only where it is needed, saving time and resources. The technology also lends itself well to long-term bandwidth-limited monitoring systems that experience few variations but could be vulnerable as anomalies occur.

More importantly, Armstrong's adaptive algorithm enhances safety, because it automatically adjusts the resolution of sensing based on real-time data. For example, when strain on a wing increases during flight, the software automatically increases the resolution on the strained part of the fiber. Similarly, as bridges and wind turbine blades undergo stress during big storms, this algorithm could automatically adjust the spatial resolution to collect more data and quickly identify potentially catastrophic failures.

This innovation greatly improves the flexibility of fiber optic strain sensing systems, which provide valuable time and cost savings to a range of applications.

For more information about the full portfolio of FOSS technologies, see DRC-TOPS-37 or visit https://technology-afrc.ndc.nasa.gov/featurestory/fiber-optic-sensing

APPLICATIONS

The technology has several potential applications:

- Structural Health Monitoring: Buildings, bridges, oil platforms, ocean vessels, aerospace vehicles, and other large structures
- Enhancing Travel Safety: Cargo load balancing, flight testing
- Active Control Handling: Truck and automobile frames and suspension, wind turbine blades, aircraft, and other flexible structures
- Medical Device Monitoring: Procedures involving endoscopes, catheters, and minimally invasive surgeries

PUBLICATIONS

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More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

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