Analysis of Experimental Data from Fiber Optic Sensors



Overview

Machine learning-empowered automatic analysis of distributed fiber. This paper presents a machine learning-empowered approach for automatically analyzing.

Key Takeaways

Experimental studies confirm that fiber optic sensors offer high sensitivity, distributed monitoring capabilities, and reliable performance across diverse applications, including structural health and pipeline monitoring.

Key Experimental Findings

Distributed Fiber Optic Sensors (DFOS): Experiments on DFOS using Stimulated Brillouin Scattering (SBS) demonstrated their ability to detect strain and pressure anomalies in High-Density Polyethylene (HDPE) pipelines. By winding optical fibers on the pipe surface, researchers successfully identified pressure changes caused by water leakage. Two experimental phases—static pressure testing and dynamic leakage detection—validated the sensors' sensitivity and accuracy.

The studies also highlighted the importance of viscoelastic modeling of HDPE to calibrate sensor responses, confirming DFOS as a viable solution for real-time pipeline monitoring and future integration into “natively smart” pipes. Fiber Bragg Gratings (FBGs): Experimental fabrication of FBGs using femtosecond laser point-by-point inscription showed that optimizing parameters such as laser energy, grating order, and focusing geometry can produce high-quality gratings with reflectivity over 99. 9% and extremely low insertion loss (0.

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03 dB).

Wavelength-division-multiplexed FB

G arrays and Fabry–Perot cavities were successfully realized, demonstrating precise spectral control and reduced birefringence. These results indicate that FBGs can provide highly accurate, multiplexed sensing for strain, temperature, and pressure measurements.

Intensity- and Wavelength-

Based Sensors: Experiments with intensity-based sensors, such as microbend and evanescent wave sensors, confirmed their simplicity, low cost, and ability to perform distributed sensing. Wavelength-modulated sensors, including Bragg gratings and fluorescence-based devices, showed high sensitivity and robustness for detecting physical parameters like strain, displacement, and pressure. Experimental studies also highlighted challenges such as light source variations and the need for referencing systems to avoid false readings.

Practical Implications

High Sensitivity and Accuracy: Fiber optic sensors reliably detect small changes in strain, pressure, or temperature, making them suitable for structural health monitoring, pipeline leak detection, and aerospace applications. Distributed Sensing: DFOS and multiplexed FBG arrays enable monitoring over long distances, providing real-time data for large-scale infrastructure. Robustness: Experiments confirm that fiber optic sensors operate effectively in harsh environments, including high electromagnetic interference, extreme temperatures, and corrosive conditions.

Future Development: Integration of sensors into materials during manufacturing (e.g., smart HDPE pipes) and advanced fabrication techniques (fs laser inscription) are expected to enhance performance, reduce installation complexity, and expand applications.

Conclusion

Experimental investigations consistently demonstrate that fiber optic sensors are highly effective, versatile, and reliable for monitoring physical, chemical, and environmental parameters. Their distributed sensing capabilities, high sensitivity, and robustness make them indispensable in modern engineering, biomedical, and industrial applications, with ongoing research focused on improving integration, multiplexing, and fabrication techniques for enhanced performance.

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Article Content

Machine learning-empowered automatic analysis of distributed fiber ...

This paper presents a machine learning-empowered approach for automatically analyzing strain data measured from distributed fiber optic sensors for monitoring coincident cracks and

Exhaustive analysis and simple model of an angular displacement

Here, we present a comprehensive analytical model for multi-axis tilt sensing based on intensity-modulated optical fiber sensors (OFDSs).

Automatic interpretation of strain distributions measured from ...

This paper proposes to automate the identification, localization, quantification, and visualization of cracks through intelligent interpretation of strain distributions measured from

Experimental Investigations of Distributed Fiber Optic Sensors for ...

In this work, we focused on the use of Distributed Fiber Optic Sensors (DFOS) based on Stimulated Brillouin Scattering (SBS) technology for monitoring water pipeline networks. We worked

Experimental Dataset for Fiber Optic Specklegram Sensing Under

This dataset supports developing and validating temperature-sensing models using fiber optic technology and can facilitate benchmarking against other experimental or synthetic datasets.

fosanalysis – A framework to evaluate distributed fiber optic sensor data

This project provides a framework for analyzing distributed fiber optic sensor data with the focus on crack width calculation. fosanalysis is developed under Python 3.9 and is available in the Python

Lab on Fiber: Recent Experimental Advances in Optical Fiber Sensor ...

Current technologies of experimental advances in sensor manufacturing are reviewed from the aspects of the fiber substrate structure, metal layer types, and film layer modification materials.

EXPERIMENTAL AND THEORETICAL RESULTS FOR STRAIN

In addition to the experiments demonstrating the possibility of measuring strains with fiber-optic strain sensors based on Bragg gratings embedded into the material, the results of a

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Intervention of Machine Learning and Explainable Artificial ...

Abstract: This letter illustrates the successful application of machine learning (ML) models with explainable artificial intelligence (XAI) to enhance the efficacy of a surface plasmon

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Optical Fiber Sensors and Sensing Networks: Overview of the Main

Optical fiber sensors present several advantages in relation to other types of sensors. These advantages are essentially related to the optical fiber properties, i.e., small, lightweight,

fosanalysis – A framework to evaluate distributed fiber optic sensor data

The rich data enables valuable insights, e.g., for monitoring crack widths or global deformations. Aggregating this data to information requires efficient and scientifically substantiated algorithms. This

Laboratory Tests Using Distributed Fiber Optical

Using fiber optics as a tool for different kinds of geotechnical monitoring can be highly attractive and cost-effective when compared to

Systematic review of fiber-optic distributed acoustic sensing ...

Distributed Acoustic Sensing (DAS) is an advanced optical fiber technique that uses Rayleigh backscattering to offer real-time monitoring and data collection across a wide range of

Achieving precise multiparameter measurements with distributed optical ...

Nageswara Lalam and colleagues demonstrate a multiparameter distributed optical fibre sensing. They employ the wavelength multiplexing technique in Brillouin and Rayleigh scattering with

Optical Fibre-Based Sensors—An Assessment of Current Innovations

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Optical fibre sensors are an essential subset of optical fibre technology, designed specifically for sensing and measuring several physical parameters. These sensors offer unique

Distributed optical fiber sensing: Review and perspective

Distributed optical fiber sensors characterized by spatially resolved measurements along a single continuous strand of optical fiber have undergone

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