

Article Overview

Distributed fiber optic sensors (DFOSs) and distributed acoustic sensors (DASs) can detect and classify signal patterns using advanced interferometric setups and deep learning algorithms for high-accuracy pattern recognition.

Overview of Fiber Optic Sensors

Distributed fiber optic sensors (DFOSs) and distributed acoustic sensors (DASs) are capable of monitoring long distances with high spatial resolution by detecting changes in light signals caused by vibrations, strain, or acoustic events along the fiber. DFOSs are widely used for intrusion detection, perimeter security, and structural monitoring, while DASs excel in detecting faint vibrations and acoustic signatures over kilometers of fiber .

Pattern Recognition Techniques

Interferometric Approaches

A Mach-Zehnder interferometer (MZI) can be combined with a time forest neural network (TFNN) to analyze signal patterns from DFOSs. This approach improves accuracy and efficiency compared to conventional one-dimensional convolutional neural networks (1D-CNNs), achieving up to 8.43% higher accuracy in intrusion detection scenarios . The interferometric method enhances sensor characterization and allows real-time signal processing in smart environments.

Deep Learning and CNNs

For DASs, deep convolutional neural networks (CNNs) are effective for classifying vibration events. Techniques such as intensity and phase stacked CNNs (IP-CNNs) utilize both intensity and phase information from coherent detection, improving classification accuracy. Data augmentation can further enlarge the training dataset, achieving classification accuracies of 88.2% for 1 km sensing lengths . These methods allow the system to distinguish between events like walking, digging, or vehicle movement.

Feature Extraction and Machine Learning

Other approaches include support vector machines (SVMs), relevance vector machines (RVMs), and artificial neural networks (ANNs) using features extracted from signal morphology, wavelet decomposition, or temporal-spatial data. These methods reduce false alarms and improve computational efficiency by focusing on relevant signal characteristics .

Applications

- o Security and Intrusion Detection: Monitoring perimeters of military bases, industrial plants, and critical infrastructure .
- o Structural Health Monitoring: Detecting strain, vibrations, or acoustic anomalies in pipelines, bridges, and buildings .
- o Smart Environments: Real-time monitoring and classification of events for automated response systems .

Key Advantages

- o High spatial resolution over long distances
 - o Real-time pattern recognition using advanced neural networks
 - o Ability to integrate both intensity and phase information for improved accuracy
 - o Flexibility to detect multiple types of events simultaneously
- Fiber optic sensors combined with modern machine learning and deep learning algorithms provide a powerful platform for accurate, real-time pattern recognition in diverse applications, from security to infrastructure monitoring .

Although the state-of-the-art fiber optic shape sensing mechanisms can provide sub-millimeter spatial resolution for off

Abstract A flexible fiber-optic sensor enabled by deep learning is proposed and experimentally demonstrated for highly

Distributed fiber optic sensors use optical fibers as sensing units, allowing them to simultaneously measure hundreds of

This research explores innovations in the measurement of optical fiber sensors for intrusion detection, focusing on

Distributed fiber optic sensors (DFOSs) have become increasingly popular for intrusion detection, particularly in outdoor and

Therefore, the integration of optical fiber sensors in WSNs introduces benefits and new capabilities for the design of advanced hybrid

Event pattern recognition technology has become an important research direction of distributed fiber optic vibration

This article proposes an intrusion pattern recognition scheme based on Gramian Angular Field (GAF) and

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Accurate pattern recognition can reduce the false alarm rate and significantly increase the stability of the optical fiber system. In this

In this work, we propose a pattern recognition algorithm using SVMD and binary tree SVM to simultaneously reduce

In recent years, pattern recognition technologies for distributed optical fiber vibration sensing have attracted more and

This chapter highlights recent developments in ML and AI that enhance fiber optic sensing (FOS) applications and

In this way, research in fiber optic sensors has moved from a focus on multiplexing techniques to improve wireless

Inspection keywords acousto-optical signal processing deep learning (artificial intelligence) distributed sensors feature

This paper presents the latest advancements in ML-based optical fiber sensors, outlines the problems faced by

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