

What is the principle of fiber optic shape sensing



Overview

Fiber Optic Shape Sensors: A comprehensive review
Fiber Optic Shape Sensing is an innovative Optical Fiber Sensing Technology that uses a fiber optic cable.

Key Takeaways

Fiber optic shape sensing determines the 3D shape of an optical fiber by measuring strain-induced wavelength shifts in embedded Fiber Bragg Gratings (FBGs) or via distributed scattering, converting these signals into curvature and spatial coordinates.

Core Principle

Fiber optic shape sensing relies on the detection of strain along an optical fiber, which occurs when the fiber bends or deforms. The most common approach uses Fiber Bragg Gratings (FBGs) inscribed in multi-core optical fibers.

Each FB

G reflects a specific wavelength of light, and when the fiber bends, the strain changes the reflected wavelength. By measuring these wavelength shifts, the local strain at multiple points along the fiber can be determined, which is then used to reconstruct the fiber's curvature and 3D shape in real time.



Multi-

Core Fiber Approach

In multi-core fibers, several cores run parallel within a single fiber. When the fiber bends, the outer cores experience tension or compression relative to the central core, producing differential strain readings. These relative strains are processed to calculate local curvature and bending orientation, which are then integrated along the fiber length to reconstruct the overall shape.

Advanced methods use polynomial approximations or deep learning models to convert strain data into precise 3D tip positions, achieving sub-millimeter accuracy. Distributed vs.

Quasi-

Distributed Sensing

Distributed sensing uses scattering phenomena such as Rayleigh, Brillouin, or Raman scattering to measure strain continuously along the fiber. Techniques like Optical Time Domain Reflectometry (OTDR) or Optical Frequency Domain Reflectometry (OFDR) provide high spatial resolution but require complex readout systems. Quasi-distributed sensing relies on discrete FBGs at specific points along the fiber, offering a simpler and commercially widespread solution, especially in medical robotics and minimally invasive surgery.

Applications

Fiber optic shape sensing is widely used in: Medical devices: Catheter navigation, instrument tracking, and minimally invasive surgery. Robotics: Real-time position tracking and deformation monitoring. Structural monitoring: Aerospace, energy, and civil engineering applications where precise shape and strain measurements are critical.

Summary

The principle of fiber optic shape sensing is based on converting strain measurements from optical fibers into curvature and spatial coordinates. Multi-core fibers with FBGs provide high-resolution, real-time shape reconstruction, while distributed scattering methods allow continuous sensing over long distances. This technology enables precise navigation, deformation monitoring, and control in complex or constrained environments.

Article Content

Fiber Optic Shape Sensors: A comprehensive review

Fiber Optic Shape Sensing is an innovative Optical Fiber Sensing Technology that uses a fiber optic cable to continuously track the 3D shape and position of a dynamic object (with unknown

Shape Sensing Fiber Optic Solutions for 3D Monitoring

Optical fiber shape sensing is a form of distributed sensing that uses scattered signals from a multi-core fiber to determine curvature and twist rate to produce the shape of a given structure.

Advances in fiber-optic-based 3D shape sensing technology

Fiber-optic shape sensing technology is fundamentally based on establishing a precise relationship between physical deformations and optical signals by analyzing non-uniform strain

Rapid and Accurate Shape-Sensing Method Using a Multi-Core Fiber

In this work, we propose a novel, computationally efficient method for determining the 3D tip position of a bent multi-core FBG-based optical fiber using a second-order polynomial

Shape Sensing

The key constituent for this type of sensing is based on simultaneous and real-time monitoring of the induced strain in a multi-core optical fiber with included draw tower grating sensors (MCF-DTG ®)

Spatial Shape Sensing of Multicore Optical Fiber Based on Distributed ...

This proposed method, which achieves shape sensing directly from distributed strain measurement of multicore optical fiber without complex computation and cumulative errors, will have

Fiber-optic sensor

Optical fibers can be made into interferometric sensors such as fiber-optic gyroscopes, which are used in the Boeing 767 and in some car models (for navigation purposes). They are also used to make

Fiber optic shape sensing

The key constituent for this type of sensing is based on simultaneous and real-time monitoring of the induced strain in a multi-core optical fiber with included draw tower grating sensors (MCF-DTG®)

Review on optical fiber shape sensing technology

Shape sensing technology based on optical fibers is a new research direction in the field of optical fiber sensing. In recent years, fiber shape sensors have used several optical fibers with a

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Fiber Optic Shape Sensors: A comprehensive review

A Fiber Optic Shape Sensor (FOSS) can be defined as fiber optic cable with multiple cores and embedded strain sensors. The working principle is the following: in each instrumented section

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Custom Maltego transforms. Contribute to michenriksen/maltego development by creating an account on GitHub.

Deep learning-based approach for high spatial

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

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Shape Sensing with Rayleigh Backscattering Fibre Optic Sensor

In this paper, Rayleigh backscattering sensors (RBS) are used to realize shape sensing of beam-like structures. Compared to conventional shape sensing systems based on fibre Bragg

Dynamic Fiber-Optic Shape Sensing Using Fiber Segment Interferometry

Dynamic fiber-optic shape sensing, often also referred to as curvature or bend sensing, is demonstrated using fiber segment interferometry, where chains of fiber segments, separated by

A Universal Shape Sensing Strategy Based on Distributed Fiber-Optic ...

This study proposes a universal shape sensing strategy to reconstruct the shape of structures with complex geometries by introducing solid elements into the inverse finite element method (iFEM). By

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