Fiber Bragg Grating Reconstruction



Overview

Abstract: This paper presents the development, analysis and application of a fiber Bragg grating (FBG) array for two-dimensional (2D) shape reconstruction in a cantilever beam.

Key Takeaways

Fiber Bragg Grating (FBG) reconstruction uses wavelength shifts from FBG sensors to accurately determine structural deflections or shapes in real time.

Overview of FB

G ReconstructionFBG reconstruction involves measuring strain or curvature along a structure using FBG sensors and converting the wavelength shifts into geometric information.

Each FB

G reflects a specific wavelength that shifts proportionally to strain or temperature changes. By arranging multiple FBGs along a structure, it is possible to reconstruct 2D or 3D shapes of beams, robotic manipulators, or continuum devices. Sensor Array DesignFBG arrays can be embedded directly into structural elements, such as wood, polymers, or medical continuum manipulators, to measure deflection or curvature.

For example, a 5-FBG array in a cantilever beam can provide highly linear deflection measurements with a determination coefficient (R^2) above 0.995, enabling accurate 2D shape reconstruction. In medical applications, FBGs embedded in continuum manipulators allow centerline reconstruction with sub-millimeter accuracy, even under large deflections and obstacles.

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Temperature Compensation

Temperature affects FBG wavelength readings, so temperature compensation is critical. One approach is to embed an additional FBG in a region with negligible strain, such as a silicone mold at the clamping point, to measure temperature independently. The measured temperature is then used to correct the strain-sensitive FBG readings, ensuring accurate reconstruction.

Reconstruction Methodology

The reconstruction process typically involves: Measuring wavelength shifts from each FBG node. Converting shifts to strain or curvature using calibration factors. Integrating curvature along the structure to reconstruct the shape or centerline.

Validating against numerical models such as finite element analysis to ensure accuracy. In continuum manipulators, the curvature-wavelength relationship is often linear, allowing real-time shape tracking with errors as low as 0.216 ± 0.126 mm for free deflections and slightly higher in constrained environments.

Applications

Structural health monitoring: Real-time deflection and strain monitoring in beams, bridges, and composite materials. Medical robotics: Shape sensing in continuum manipulators for minimally invasive surgery. Aerospace and mechanical systems: Embedded FBG arrays for monitoring wing or fuselage deformation.

FB

G reconstruction provides high sensitivity, real-time monitoring, and the ability to embed sensors directly into structures, making it a versatile tool for both engineering and biomedical applications.

Article Content

Fiber Bragg Grating Array for Shape Reconstruction in Structural

Abstract: This paper presents the development, analysis and application of a fiber Bragg grating (FBG) array for two-dimensional (2D) shape reconstruction in a cantilever beam. The structural elements

Fiber Bragg Grating Array for Shape Reconstruction in Structural

Introduction¶T ¶T DD D2.4. Numerical AnalysisInformed Consent Statement: Not applicable.mechanical or civil structure is subjected to different types of stress throughout its lifespan. These stresses can range from static to dynamic (e.g., car traffic atop a bridge, wind gusts, and earthquakes). In order to ensure the proper operation of these structures, health monitoring is necessary, implying greater control and security. As a resu...See more on pdfs.semanticscholar nih.gov

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Fiber Bragg Grating Array for Shape Reconstruction in Structural ...

This paper presents the development, analysis and application of a fiber Bragg grating (FBG) array for two-dimensional (2D) shape reconstruction in a cantilever beam.

2D shape reconstruction with Fiber Bragg Gratings embedded in

The proposed sensor system is based on the optical fiber integration between two rubber layers, where the optical fibers have 7 FBGs for the quasi-distributed force assessment.

Design and Fabrication of a Fiber Bragg Grating Shape Sensor for

This study presents a novel approach for the design and fabrica-tion of a large deflection fiber Bragg grating (FBG) shape sensor embedded within the lumens inside the walls of a CDM with a large

Spatial shape reconstruction using orthogonal fiber Bragg grating ...

With distributed orthogonal fiber Bragg grating (FBG) sensor arrays used as modular detection units, an implementation method for deformation detection and spatial shape

Fiber Bragg grating plate structure shape reconstruction algorithm ...

Abstract A space curved surface shape reconstruction algorithm is proposed for shape perception and reconstruction of flexible plate structure. First, biorthogonal strain data measured by

Structural shape reconstruction of fiber Bragg grating flexible plate ...

This article shows how to implement structural shape reconstruction using a small number of stain data measured by fiber Bragg grating sensors. First, the basic theory of structural

Fiber Bragg Grating Sensors: Design, Applications, and ...

Fiber Bragg grating (FBG) sensors have emerged as advanced tools for monitoring a wide range of physical parameters in various fields, including structural health, aerospace, biochemical,

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

Shape-sensing optical fibers have become increasingly important in applications requiring flexible navigation, spatial awareness, and deformation monitoring. Fiber Bragg Grating (FBG)

Fiber Bragg grating-based shape sensing: a review and perspective

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In numerous studies, fiber Bragg grating (FBG) based shape sensing has been used for measuring the deflection of continuum robots on larger scales, but has proved to be a challenge for

Chirped apodized fiber Bragg gratings inverse design via deep

Overcoming inverse design problems in fiber Bragg gratings (FBGs) can be challenging due to the significant nonlinearity of the problem and the intric

Design and Fabrication of a Fiber Bragg Grating Shape Sensor for

Design and Fabrication of a Fiber Bragg Grating Shape Sensor for Shape Reconstruction of a Continuum Manipulator Abstract: Continuum dexterous manipulators (CDMs) are suitable for

Shape sensing technology based on fiber Bragg grating for flexible ...

Shape sensing techniques based on fiber Bragg grating (FBG) sensors capture geometric information, such as curvature and torsion, by inscribing multiple FBGs into optical fibers

Design, Measurement and Shape Reconstruction of Soft Surgical

Soft actuators are the components responsible for organs and tissues adsorptive fixation in some surgical operations, but the lack of shape sensing and monitoring of a soft actuator greatly

A Robust Graph-Based Framework for 3-D Shape Reconstruction of

This paper proposes a novel graph-based framework for 3-D shape sensing of flexible medical instruments using multi-core fiber Bragg grating (FBG) sensors. Due to noisy signals,

[2303.03613] Design and Fabrication of a Fiber Bragg Grating Shape ...

Design and Fabrication of a Fiber Bragg Grating Shape Sensor for Shape Reconstruction of a Continuum Manipulator Golchehr Amirkhani, Anna Goodridge, Mojtaba Esfandiari, Henry

Reconstruction of strains with a non-smooth ...

The paper presents a reconstruction of strains with a non-smooth distribution affecting the optical fiber Bragg grating based on its reflection intensity spectrum.

2D and 3D Shape Sensing Based on 7-Core Fiber Bragg Gratings

A fiber-optic shape sensing based on 7-core fiber Bragg gratings (FBGs) is proposed and experimentally demonstrated. The investigations are presented for two-dimensional and three

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