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Solving the inverse scattering problem with differential evolution: an experimental validation

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***Abstract*— This work shows the experimental validation of a method developed for determining the strain profile applied to a fiber Bragg grating by solving the inverse scattering problem. The non-uniform strain profile is recovered by formulating an optimization problem, solved with an algorithm based on differential evolution. The method has proved to be able of recovering the shape and approximate amplitude of the actual strain profile applied to the FBG, opening new perspectives for optical sensing with fiber Bragg gratings.**

***Index Terms*—** Computational Intelligence, Differential Evolution, Fiber Bragg Gratings, Optical Sensors, Strain Sensing.

I. INTRODUCTION

Nowadays, fiber Bragg gratings (FBGs) are widely used in strain and temperature sensing systems [1]. The FBG consists of a periodic refractive index modulation, usually produced in the core of an optical fiber by the incidence of a UV-laser interference pattern. FBGs operate as selective mirrors, back-reflecting those wavelengths of the light propagating in the fiber core that satisfy the Bragg condition. Mechanical deformations and changes in temperature affect the FBG periodicity and the refractive index modulation, changing the Bragg condition and, consequently, the FBG reflection spectrum. Spectral shifts of the FBG resonance are the basis for the device operation as sensor. Most techniques of interrogation are based on algorithms used to detect the peak position of the FBG resonance [2],[3]. This strategy allows, e.g., punctual or quasi-distributed sensing of strain and temperature [1], [4]-[6] if the spectral wavelength shifts result from a uniform FBG deformation or a temperature change that affects the whole grating. Nevertheless, a non-uniform profile of strain or temperature results in additional spectral alterations such as broadening, splitting and asymmetrical shifts of the FBG resonance [7]. Such spectral features are usually detrimental for the sensor operation in most of the cases, but may become an asset if properly addressed. A non-uniform profile of strain or temperature applied to the FBG can be recovered by solving the inverse scattering problem, allowing multi-point monitoring with a single FBG in a distributed sensing configuration. This approach can benefit quasi-distributed sensing systems, leading to a reduction in the number of

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