Hindawi
Journal of Sensors
Volume 2018, Article ID 6506239, 8 pages
https://doi.org/10.1155/2018/6506239

Research Article

Tactile Sensor Array with Fiber Bragg Gratings in Quasi-Distributed Sensing

Marcelo A. Pedroso,[1] **Lucas H. Negri**,[2] **Marcos A. Kamizi**,[1] **José L. Fabris**,[1] **and Marcia Muller**[1]

[1]*Graduate Program in Electrical and Computer Engineering, Federal University of Technology-Paraná, Curitiba, PR, Brazil*
[2]*Federal Institute of Education, Science and Technology of Mato Grosso do Sul, Aquidauana, MS, Brazil*

Correspondence should be addressed to José L. Fabris; fabris@utfpr.edu.br

Received 30 August 2017; Accepted 14 December 2017; Published 13 February 2018

Academic Editor: Carlos Ruiz

Copyright © 2018 Marcelo A. Pedroso et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

This work describes the development of a quasi-distributed real-time tactile sensing system with a reduced number of fiber Bragg grating-based sensors and reports its use with a reconstruction method based on differential evolution. The sensing system is comprised of six fiber Bragg gratings encapsulated in silicone elastomer to form a tactile sensor array with total dimensions of 60×80 mm, divided into eight sensing cells with dimensions of 20×30 mm. Forces applied at the central position of the sensor array resulted in linear response curves for the gratings, highlighting their coupled responses and allowing the application of compressive sensing. The reduced number of sensors regarding the number of sensing cells results in an undetermined inverse problem, solved with a compressive sensing algorithm with the aid of differential evolution method. The system is capable of identifying and quantifying up to four different loads at four different cells with relative errors lower than 10.5% and signal-to-noise ratio better than 12 dB.

1. Introduction

Some works have pointed to the use of arrays of fiber Bragg grating- (FBG-) based transducers in tactile sensing systems (TSS) applied to the mapping of forces in robotic systems [1], biomedical [2], and medical areas [3, 4]. These systems make use of the FBG multiplexing capability. Despite the limitations in the number of FBG that can be multiplexed, FBG-based sensors enable multipoint monitoring in a quasi-distributed configuration.

Different approaches have been proposed for the development of sensor arrays. Such strategies include gluing grating-based transducers directly under the surface of a steel or polymethyl methacrylate (PMMA) plate [5, 6], attaching gratings to iron rings [7], encapsulating FBGs in blocks of silicone positioned under a steel plate [8], or forming an array of sensors in a single silicone encapsulation [1, 9].

The embedding of many FBG in a single thin sheet of a host material makes the tactile sensor array (TSA) flexible, so that it can be adapted to surfaces with different forms. Among the manufacturing methods, molding is a low-cost process that allows an easy encapsulation of a set of FBG sensors [9].

Some tactile sensing systems use one sensor element dedicated to each point of sensing, requiring an increased number of elements if the area of monitoring is wide. Under these conditions, the cost and complexity of the sensing system also increase. Nevertheless, this number can be reduced if the responses of the sensor elements in the TSS are coupled, making such a system less expensive and more robust [6].

Computational methods as artificial neural networks [10, 5] and fuzzy rule-based systems [6] have been used to interpret data from sensing systems. In an effort to further reduce the number of elements of a sensing array, Negri et al. [7] reported the development of a tactile sensing system with an array of sensors in a quasi-distributed configuration. In this system, a metal plate was divided into nine square regions monitored by seven FBGs installed in metal rings. The application of compressive sensing theory [11] to the underdetermined inverse problem resulting from this