University of Basel
Department of Biomedical Engineering

Project MIRACLE
Planning and Navigation
CIAN

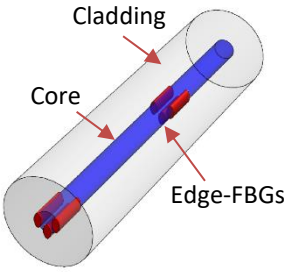
Master Thesis Proposal

Modeling Edge-FBG Shape Sensors Using Supervised Deep Learning

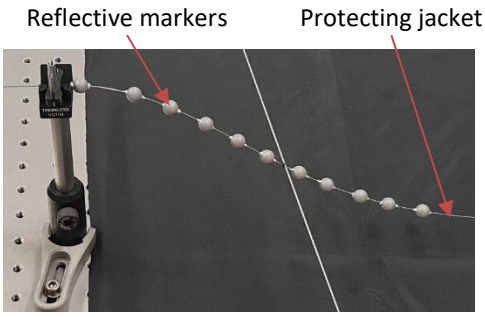
Context

In minimally invasive surgeries, it is often required to use non-rigid instruments in order to maximize accessible regions. However, the main drawback of using flexible tools is the higher risk of damaging non-target tissues as there is uncertainty about their shape. Consequently, an accurate tracking system is needed. Shape sensors based on Fiber Bragg Gratings (FBG) are suitable for this task because they are small, biocompatible, immune to electromagnetic interference, and require no line of sight.

One of the most recent types of these sensors is based on Edge-FBGs, where the Bragg gratings are inscribed on the edge of the core in a single-mode optical fiber (Fig. a). External perturbations such as mechanical strain and temperature cause changes in the amplitude of the Bragg peaks. The main challenge in these sensors is to accurately model their behavior as the main signal is often affected by other undesired phenomena. Preliminary results show that the complicated relationship between the amplitude of the Edge-FBGs and the sensor's shape can be described using a basic deep learning algorithm.



a) Edge-FBG sensor.



b) Data acquisition setup.

Task description

This master thesis aims to improve the data acquisition setup and develop a more advanced algorithm to model the Edge-FBG sensor. The following steps describe the work packages:

- A plastic jacket with attached passive reflective markers is used to measure the shape of the Edge-FBG sensor (shown in Fig. b). The spatial coordinates of the markers are estimated using a motion capture system. The high flexibility of the protecting jacket makes it challenging to cover all possible shapes during training. Therefore, your first task is to provide a constrained environment to have more control over the deflections.
- A fast spectrometer controlled by MATLAB collects the output signal of the sensor. You need to synchronize it with the motion capture system to find the corresponding shape.
- Different Deep learning architectures should be tested to find the most accurate model describing the sensor's behavior.

Specific Requirements

Experience with MATLAB, Motion Capture Systems, and Optical Fibers.

Supervision

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