Feasibility Study on Using Supervised Deep-Learning to Model Edge-FBG Shape Sensors

Figure 1: The experimental setup used for training data collection .The sensor's real shape and the edge-FBG spectrum were measured using a motion capture system and a fast spectrometer respectively (Picture: T. Renna).

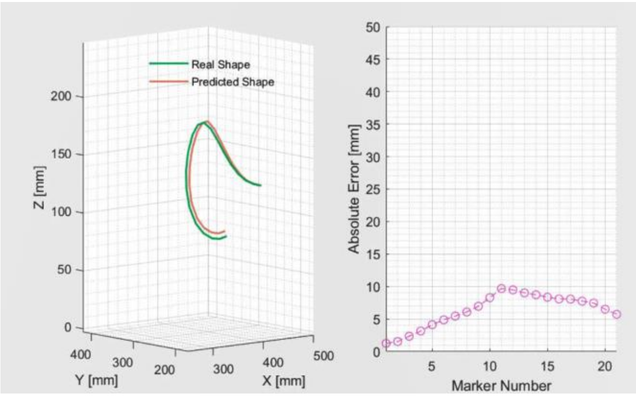

Figure 2: An example of the predicted shape with less than 10 mm tip error (Picture: T. Renna).

Master Thesis by Tatiana Renna at Planning and Navigation Group.

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. Fiber shape sensors are suitable for tracking these tools inside the patient's body as they are small, biocompatible, immune to electromagnetic interference, and require no line of sight. One of the most recent types of fiber shape sensors is based on edge fiber Bragg gratings (edge-FBG), a single-mode fiber with Bragg gratings around the edge of its core. The amplitude of the Bragg peaks in such sensors contains the strain information. However, undesired bending related phenomena affect the spectrum profile of the gratings in an unpredictable way making the classical approach insufficient in shape estimation.

This project aimed to study the feasibility of modeling edge-FBG sensors with deep learning. We showed that neural networks can be trained to predict the sensor's shape, given the edge-FBG spectrum. The implemented architecture can detect medium to large deflections in a 300 mm sensor with an average tip positioning error of 17 mm.

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Supervision:
Samaneh Manavi
samaneh.manavi@unibas.ch

Dr. Antal Horváth
antal.horvath@unibas.ch

Prof. Dr. Philippe Claude Cattin
philippe.cattin@unibas.ch