Image-Guidance Research In Colonoscopy to Improve Diagnosis Of IBD

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INTRODUCTION

Background: Colonoscopy is the current gold standard for inflammatory bowel disease (IBD) diagnosis and colorectal cancer screening. Even though colon cancer is 90% successfully treated if detected at an early stage, the compliance rate for screening is only 30% in the United States. Difficulties in performing colonoscopy, such as looping in the colon (Figure 1) and disorientation, are due to the limited control in manipulating the flexible endoscope (Figure 2) and near-blind navigation through the non-rigid colon, causing a great deal of discomfort, and potentially injuries, to patients.

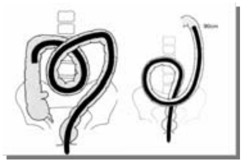

FIGURE 1. Common loops that can form during a colonoscopy.

FIGURE 2. Flexible endoscope (colonoscope).

GOAL

Goal: To create a navigational aid that provides a 3D view of the scope inside the colon, in real-time, to guide the clinician in performing colonoscopy. This requires the development of a sensor that is capable of tracking the 3D shape of the colonoscope. The data from the sensor can then be used to render a graphical display to augment the endoscopic view (Figure 3).

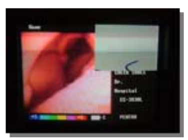

FIGURE 3. Proposed navigational aid [1].

Innovation: The shape tracker is constructed using a single modified optical fiber [2]. Fluorescent dyes are embedded in strategic locations along the length of the fiber. Light passing through the fiber will excite the dyes, which will fluoresce with varying intensities as a function of the local curvature of the optical fiber. The single-fiber shape tracker is small enough to be easily implemented by inserting it into the colonoscope through the biopsy channel.

EXPERIMENTAL SETUP

Fiber Modification: A 100 µm hole was cut in the buffer, penetrating to the cladding of the fiber. The hole was then filled with a unique fluorescent dye and glue mixture. This represented a distinct location on the fiber, marked by the unique emission wavelength of the dye when excited by the leaked laser light propagating through the fiber core.

Testing the Modified Fiber: Our experimental setup consisted of a 632.8 Nm He-Ne laser, and a spectrometer (Figure 4). A 200 nm silica-core fiber, embedded with the selected dye, was bent around a series of cylinders with pre-determined curvatures. Dye fluorescence emission intensity was recorded as a function of fiber curvature.

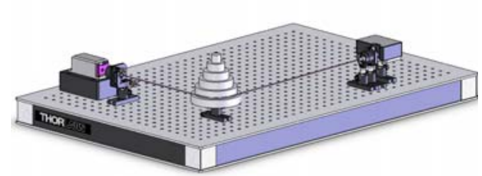

FIGURE 4. Experimental setup used to test the fluorescence intensity and a function of fiber curvature.

RESULTS

Data showed that as the curvature increases the intensity of the fluorescence also increases. Figure 5 represents a sample relationship between fluorescence intensity and curvature for our modified fibers. This, although bending only in one dimension, demonstrates the concept that a shape tracker based on a single optical fiber is feasible. Up to 40% change in emission intensity was possible when the fiber was bent from a bending radius of 58 mm to 11 mm.

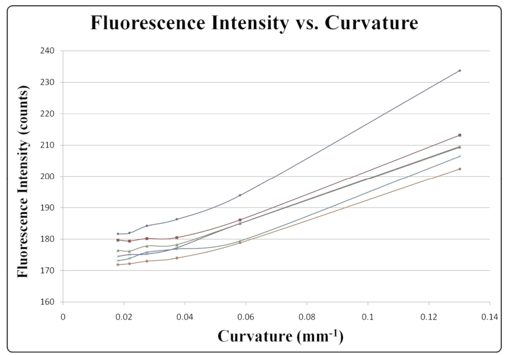

FIGURE 5. Fluorescence intensity from a modified fiber as a function of curvature. The fluorescent dye used was LD 700, with emission signals integrated over 20 ms, and measured at 700.17 nm.

FUTURE WORK

We will optimize the methods and techniques for modifying the fiber, and begin to experiment with quantum dots (QD) as fluorescent markers for the shape tracker. Once we have identified at least 6 distinct QDs, we will:

1. Calibrate signals in 1D, 2D, and 3D
2. Optimize the fluorophore spacing on the fiber
3. Build multiple sensor segments for testing

REFERENCES

[1] Cao, C.G.L. & Milgram, P. (2007). Direction and location are not sufficient for navigating in non-rigid environments – an empirical study in augmented reality. *Presence: Teleoperators and Virtual Environments*, 16(6), 584-602.

[2] US patent application. EFOST, Caroline G. L. Cao, Lothar Lilge, Paul Milgram, Peter Y. Wong, October 11, 2007. 60/979,246.

ACKNOWLEDGEMENTS

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