ANALYSIS AND REALIZATION OF MULTIMODE FIBER MICRO-ENDOSCOPE

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Shrinking the diameter of current endoscopes is a challenging problem, which can greatly benefit medical imaging and photodynamic therapy techniques. Lately, different groups have proposed and demonstrate the ability to calibrate and use a multimode fiber (MMF) as an endoscope using a variety of techniques [1-3]. MMFs are ideal for this task due to their small diameter and bending capacity. However, these techniques are limited because the fiber has to remain unperturbed during the experiment.

We study how different types of MMFs perform as endoscopes. A careful theoretical analysis allows us to predict the performance of each MMF as an endoscope. Furthermore, we compare the degradation of a focus created at the distal tip of the fiber when a perturbation is applied and demonstrate that proper fiber selection leads to significant improvements in robustness.

As a result, we utilize the MMF with the best performance to demonstrate its capabilities as an endoscope. Using a digital micro-mirror device (DMD TI-DLP Discovery 4100) we manipulate the phase of the input wavefront incident onto the fiber at 22kHz [4]. Our system controls 4096 input spatial modes to measure the transmission matrix (TM) of the MMF using a Hadamard orthonormal basis set [5]. The TM relates the spatial input modes of the illumination with the spatial output modes at the distal tip of the MMF. With the TM information, we create a focus at the distal tip of the fiber and scan it in two dimensions. Measuring the fluorescence signal that is emitted back through the fiber while scanning the focus, we reconstruct microscopic fluorescence images. Figure 1 shows an experimental image of a sample composed of 4µm diameter fluorescence beads, imaged with a fluorescence microscope and with the MMF endoscope, demonstrating the MMF endoscope is able to resolve the 4µm beads.

Bibliography