Low-cost, multispectral imaging mini-microscope for longitudinal oximetry in small animals.

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Abstract: We present a multispectral imaging mini-microscope for longitudinal oximetry in small animals. By replacing expensive and complex imaging systems using a low-cost imaging system.

OCIS codes: (110.0110) Imaging systems; (170.0170) Medical optics and biotechnology; (110.2760) Gradient-index lenses; (280.0280) Remote sensing and sensors.

1. Introduction

The aim of this low-cost mini-microscope is to achieve a system capable of multispectral imaging analysis (MIA) in real time that can be adapted and modified according the needs of the research and researchers in low resource settings or remote places using a rechargeable battery pack. *In-vivo* microscopic imaging techniques i.e. oximetry on mice and rats is widespread and increasing animal models are used extendedly in biomedicine, for drug discovery and tracking disease progression. The number of animals experimented upon continues to rise year on year. We propose an *in-vivo* imaging system that has the promise to reduce the number of animals by permitting collection of high-resolution imaging and spectroscopy data in longitudinal repeated-measures studies especially the oxygen consumption in deep tissue that has been proved that has a relationship to different diseases [1-2, 4-5].

2. Critical imaging elements

An imaging system was created and designed in-house using; red LED (625nm), amber LED (590nm), green LED (525nm) and blue LED (475nm), dichroic optical blocks (Thorlabs - CM1-DCH/M), longpass dichroic mirrors (Thorlabs), focusing lenses, heat sinks (*Figure 2*). Universal port that holds a GRIN lens (GRINtech), fiber-array structured illumination adapted to Raspberry Pi camera, those were used to build a low-cost system for imaging [3]. In addition, the system is capable of directing the illumination into an annular illumination pattern, allowing a single pass illumination [5], i.e. reducing the complexity of the oxygenation measurement in deep tissue and blood vessels or for a better understanding of axonal remyelination, multiple sclerosis research, immune cells in lymph nodes and towards a cure for rheumatoid arthritis. The universal imaging sensor; is constituted by a Pi camera (resolution 5-megapixel, 2592x1944-pixel static images) and 3D holder for the GRIN lens and the illumination fibers, with a locking mechanism to improve coupling between the camera and the GRIN lens (*Figure 1*).

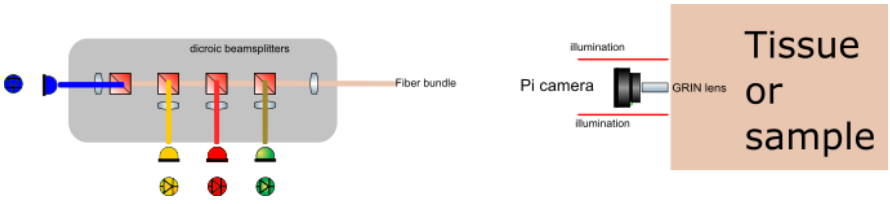

Fig. 1. Critical imaging elements.

3. Research applications for imaging laboratories

The developed system will enable a longitudinal study using transmission on a single animal over a period of up to two months. This single contributory factor reduces the number of animals used by typically a factor four or five. The reduced variability inherent in longitudinal studies of single animals will enable high quality data to be attained using fewer cross-sectional-study animals: overall, we aim for a ten-fold reduction in the number of animals that are required to be terminated.

Fig. 2. Imaging System completely assembled and operational.

4. Experimental demonstrations

Recent evidence has implicated mitochondrial dysfunction, and hypoxia, in the aetiology and pathology of multiple sclerosis (MS) and experimental autoimmune encephalomyelitis, an animal model of MS [4, 5]. The role of these pathological changes in neurological dysfunction, lesion formation, and disease progression remains unclear. *In vivo* rodent spinal-cord imaging and vessel oximetry using hyperspectral imaging in terminal experiments. Obvious differences in the vasculature (such as diameter, number, and oximetry) have been observed that correlate with measures of disease severity and neurological dysfunction in rats with EAE during the early stages of disease. For experimental purposes images recorded from a hyperspectral image sequence of the exposed rat spinal cord (approximately 300μm diameter) and dorsal vein are shown in (*Figure 3a*).

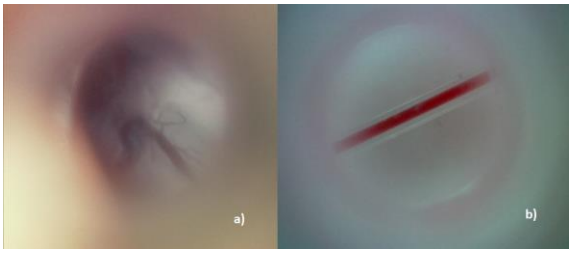

Fig. 3. (a) Rat spinal cord vasculature imaged. Oximetry is based on varying intensity of blood vessels with wavelength. (b) Image taken from a vascular phantom FEP Tubing (Fluorinated Ethylene Propylene) filled with horse blood for oximetry validation technique.

5. Conclusion

We highlighted a multispectral imaging mini-microscope for longitudinal oximetry in small animals, allowing microscopy imaging deep tissue in the brain or the spinal cord to monitor the change of oxygen in the blood vessels. This mini- microscope has significant potential to provide insightful information about the oxygen in real time.

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6. References

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