Low-Cost Stain-free Computational Spectral Fluorescence Imager for Diagnosis of Diseased Tissues

Effective and timely diagnosis is critical for successful disease treatment. Yet, conventional diagnostic methods often involve invasive procedures, high costs, and limited accessibility, particularly in resource-restricted areas. One promising alternative to traditional invasive diagnostic methods is optical biopsy. Unlike conventional biopsy techniques that require tissue extraction, optical biopsy allows for real-time, non-invasive visualization of tissue morphology and pathology. It provides immediate and accurate results, greatly reducing patient discomfort and the risk of complications, as well as overall healthcare costs. However, current optical biopsy methods, reliant on contrast agents and requiring expensive equipment and skilled personnel, are challenged by potential inaccuracies, slow operation speeds, and high costs. Fluorescence microscopy could potentially overcome these limitations. This technique offers high specificity and sensitivity in visualizing cellular components, yet traditional fluorescence microscopy requires tissue labeling with dyes and lacks the necessary spectral information to identify specific disease markers, compromising the accuracy of diagnosis. To address these challenges, we propose the low-cost Computational Spectral Fluorescence Imager. This innovative technology combines the benefits of label-free fluorescence microscopy and optical biopsy, offering three key features:

1. **Multiplex Color Imaging**: The proposed system is designed for direct compressive imaging of multiple fluorescence contrasts, facilitating multiplex color imaging. This design will potentially overcome the limitations of current color imaging techniques, offering the capability to simultaneously image multiple fluorescence contrasts. This feature will greatly enhance the system's ability to differentiate and classify multiple entities in complex tissue environment.
2. **Rapid Optical Biopsy**: The proposed work will also enable rapid compressive imaging of autofluorescence images. By leveraging cutting-edge data compression techniques, we aim to significantly increase the speed of optical biopsy procedures. This will streamline data acquisition and processing, making the procedure more efficient and accessible while maintaining high diagnostic accuracy.
3. **Advanced Signal Analysis**: Lastly, the unique feature of the system will allow for higher-level analysis of detected signals that mix the multidimensional information of the tissue of interest, enabling applications such as classification of tissue types, disease types, and more.

By providing an affordable, non-invasive diagnostic tool, this proposal has the potential to democratize healthcare, particularly in low-resource areas, while serving as a precise, cost effective, and non-invasive imaging tool for broad biomedical research.

Backing this proposal signifies support for meaningful health advancements in underserved areas and for advancing biomedical research. The Computational Spectral Fluorescence Imager, at the intersection of optics, biotechnology, and information theory, is a practical, cost-effective solution to enhance disease diagnostic quality and to catalyze advances in global health.