Ultrastruktūrinis bio-vaizdinimas su polarimetriniu netiesiniu optiniu mikroskopu

Ultrastructural Bio-imaging with Polarimetric Nonlinear Optical Microscopy

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Advanced optical microscopy is experiencing a renaissance by breaking the diffraction limit of spatial resolution, providing imaging at video frame rates and achieving deep tissue imaging. Significant advancements in microscopy are realized by employing nonlinear light-matter interactions. Many biological structures, when exposed to high intensity femtosecond laser radiation, exhibit harmonic generation effects, and hence, do not require labeling with dyes that can potentially disrupt the functionality of the system.

In this lecture, novel double and triple Stokes-Mueller polarimetry formalism will be reviewed [1, 2] and examples of polarimetric second harmonic generation (SHG) [3] and third harmonic generation (THG) [4] microscopy imaging will be presented. The nonlinear Stokes-Mueller polarimetric microscopy enables to extract ultrastructural information from each voxel of the imaged area, beyond the diffraction limited resolution. Sampe images can be constructed containing structural maps with various information such as crystallographic symmetry and orientation, nonlinear susceptibility ratios, degree of polarizations and disorder parameter (in the form of entropy) for each pixel of the image. The detailed ultrastructural information can be employed for material science, biological and biomedical studies.

Nonlinear digital histopathology investigations with polarimetric SHG and THG microscopy will be reviewed and imaging examples will be given for lung, thyroid, breast and pancreas tumors. The polarimetric SHG microscopy can be applied for routine cancer diagnostics together with standard hematoxylin and eosin labeled (H&E) pathology slides [5].

The examples of ultrastructural studies of human heart conduction system will be shown. Label-free, wide-field video-rate microscopy will be presented. Live imaging of muscle cell contractions is achieved with the wide-field microscopy at a single sarcomere spatial resolution. The live imaging of muscle contraction can be used as an investigation platform for contractility research and discovery of new antiarrhythmic agents.

The presentation will be concluded with the overview of future directions of nonlinear optical microscopy in biomedical imaging.

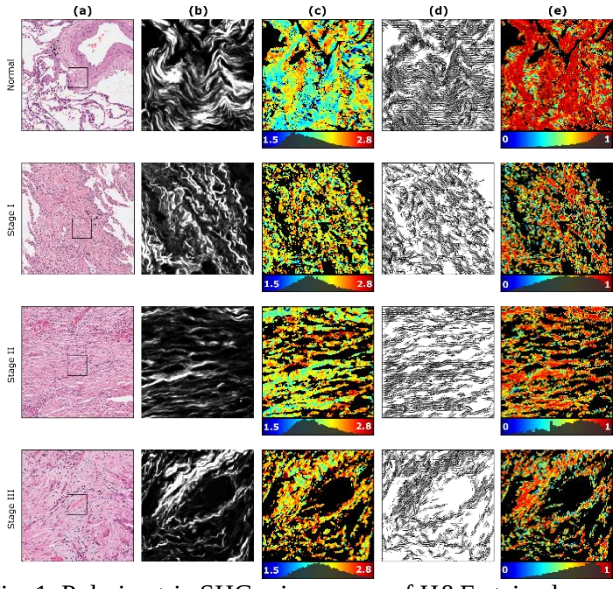

Fig. 1. Polarimetric SHG microscopy of H&E stained normal and malignant lung tissue. Column (a) shows bright-field microscopy images with square indicating area of 110 μm×110 μm used for SHG imaging (columns b to e), (b) SHG intensity images, (c) the susceptibility ratio map, (d) the fibril orientation map, and (e) the degree of linear polarization map.

Keywords: nonlinear Stokes-Mueller polarimetry, polarimetric second harmonic generation microscopy, ultrastructural microscopy, collagen, cancer diagnostics.

References

[1] M. Samim, S. Krouglov, and V. Barzda, J. Opt. Soc. Am. B, **32**, 451 (2015).

[2] M. Samim, S. Krouglov, and V. Barzda, Phys. Rev. A., **93**, 0138471 (2016).

[3] L. Kontenis, M. Samim, A. Karunendiran, S. Krouglov, B. Stewart, and V. Barzda, Biomed. Opt. Express, **7**, 559 (2016).

[4] L. Kontenis, M. Samim, S. Krouglov and V. Barzda, Opt. Express, **25**, 13174 (2017).

[5] M. Burke, A. Golaraei, A. Atkins, M. Akens, V. Barzda and C. Whyne, J. Struct. Biol. **199**, 153 (2017).