Micro - and Nanoscale Optical Imaging of Biological Species and Advanced Materials

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Modern investigation frameworks used for the characterization of biological matter, advanced materials or devices rely on a wide variety high-resolution imaging modalities. Among these, optical nanoscopy techniques are gaining increasing interest, as their resolution capabilities can render significant breakthroughs in multiple key scientific domains, as highlighted by the 2014 Nobel Prize in Chemistry awarded for the advent of "super-resolved fluorescence microscopy". The Center for Microscopy-Microanalysis and Information Processing at POLITEHNICA Bucharest (CMMPI-PB) focuses on research devoted to the development of various applications of light and scanning probe microscopies in life and materials sciences, and to the development of novel microscopy/nanoscopy techniques. The design and implementation of digital image processing and data analysis methods represent important topics of interest as well, with microscope image enhancement and bioimage classification standing among the most prominent applications in this area.

In this talk I will present the basic concepts of a series of techniques available at CMMPI-PB, along with research results obtained in recent years in the frame of national and European research projects. Specifically, I will discuss notable applications of several types of microscopy and nanoscopy techniques covering optical resolutions in the 500 microns – 1 nanometer range (e.g. Brightfield Microscopy, Confocal Microscopy, Re-scan Confocal Microscopy, Image Scanning Microscopy, Second Harmonic Generation Microscopy, Two Photon Excited Fluorescence, Stimulated Emission Depletion Microscopy, scattering-type Scanning Near-Field Optical Microscopy, etc.). In this context, I will also highlight the advantages of a home-made prototype system for correlative multimodal imaging, capable to acquire registered images with distinct far-field and near-field microscopy/nanoscopy techniques based on complementary contrast mechanisms and operating at different scales. In the final part of this talk, I will provide an overview of recent work at CMMIP-UPB bridging artificial intelligence and bioimaging.

Relevant works:

1. Stanciu, S. G., et al. "Characterization of nanomaterials by locally determining their complex permittivity with scattering-type scanning near-field optical microscopy." *ACS Applied Nano Materials* 3.2: 1250-1262 (2020).
2. Huttunen, M. J., et al. "Multiphoton microscopy of the dermoepidermal junction and automated identification of dysplastic tissues with deep learning." *Biomedical optics express* 11.1: 186-199 (2020).
3. Lucidi, M., STED nanoscopy of KK114-stained pathogenic bacteria. *Journal of Biophotonics*, *13*(9), e202000097 (2020).
4. Lucidi, M., et al. "SSNOMBACTER: A collection of scattering-type scanning near-field optical microscopy and atomic force microscopy images of bacterial cells." *GigaScience* 9.11 (2020): giaa129 (2020).
5. Stanciu, S. G., Scattering-type scanning near-field optical microscopy of polymer-coated gold nanoparticles. *ACS omega*, *7*(13), 11353-11362 (2022).
6. Stanciu, S. G., et al. "Super-resolution re-scan second harmonic generation microscopy." *Proceedings of the National Academy of Sciences - PNAS* 119.47: e2214662119 (2022).
7. Anton, S. R., et al. "Automated Detection of Corneal Edema With Deep Learning-Assisted Second Harmonic Generation Microscopy." *IEEE Journal of Selected Topics in Quantum Electronics* 29.6: Photonic Signal Processing: 1-10 (2023).
8. Stanciu, S. G., et al (2023). Toward next-generation endoscopes integrating biomimetic video systems, nonlinear optical microscopy, and deep learning. *Biophysics Reviews*, *4*(2) (2023).
9. Belhassen, Jeremy, et al. "Toward augmenting tip-enhanced nanoscopy with optically resolved scanning probe tips." *Advanced Photonics Nexus* 2.2: 026002-026002 (2023).
10. Tranca, D. E., Nanoscale local modification of PMMA refractive index by tip-enhanced femtosecond pulsed laser irradiation. *Applied Surface Science*, *623*, 157014 (2023).