336547 (2.5 points): Computational optical imaging in bio-medical engineering

What
The course focuses on computational aspects of modern optical imaging and microscopy methods, motivated by bio-imaging. We will deal with the theory as well as real-world experimental possibilities/limitations. The course includes computerized homework exercises aimed at enhancing the understanding of the various techniques as well as exposing students to actual implementation details.

When/where/who
Lectures: Sun. 10:30-12:20, (Yoav Shechtman - yoavsh@bm.technion.ac.il)
Tutorials: Sun. 12:30-13:20, (Alon Saguy - alonsaguy@campus.technion.ac.il)

Syllabus
- Introduction to computational imaging
- Fourier optics – short review (transfer function, coherent/incoherent imaging, numerical microscope model)
- Introduction to inverse problems (forward linear problems: continuous & matrix forms, Ill-posed & ill conditioned problems, regularization methods, compressed sensing example)
- Localization microscopy (imaging modalities: PALM, STORM, PAINT, emitter fitting methods, theoretical limits of localization microscopy, temporal information: 3B, SOFI)
- Single particle tracking (tracking algorithms, Kalman filter, motion blur)
- Illumination based microscopy (FCS, SIM, Ptychography, STED)
- Optical Fourier Processing (phase retrieval, adaptive optics)
- Point-Spread-Function engineering for 3D imaging and more (EDOF, 3D imaging, multispectral imaging)
- Machine learning applications in optical microscopy.
- Extra related topics (tentative: coherent diffractive imaging, phase solving in crystallography, electron cryomicroscopy, imaging through scattering media)

Grade
The grade will be determined according to:
- Computational homework exercises (Matlab or similar) - 50%
- A presentation on a topic from recent published literature - 50%

Prerequisites
Optics course (114210 / 336533 or similar), signal-processing course (044198 or similar). Special cases – please contact the lecturer.

Literature:
Classical textbooks

Other
- Various research papers in the relevant fields.