Non-invasive Imaging with Scattered Light

Ori Katz[1]
[1]*Department of Applied Physics,*
The Hebrew University of Jerusalem 9190401 Jerusalem, ISRAEL
e-mail: orik@mail.huji.ac.il

Random scattering of light in complex samples such as biological tissue renders most objects opaque to optical imaging techniques. However, although random, scattering is a deterministic process, and it can be undone, and also exploited by controlling the incident optical wavefront. These insights form the basis for the emerging field of optical *wavefront-shaping* [1]. Opening the path to new possibilities, such as imaging through visually opaque samples and around corners [2].

Standing in the way of widespread applications of wavefront-shaping are two challenges: How to determine the required wavefront correction without accessing the target side? and how to do it faster than the dynamics of the sample?

I will present some of our recent efforts in addressing these challenges [3-11]. These include the guidance of wavefront-shaping using non-linear effects [3], the photoacoustic effect [4-6], and acousto-optics [7-8]. In addition, I will show how one can exploit the dynamics of the samples instead of fighting them. I will also demonstrate how it is possible to image through scattering layers and 'around corners' using nothing but a smartphone camera [9], using correlations of scattered light.

If time permits, I will present the use of these principles for endoscopic imaging through optical fibers [10-11].

REFERENCES

[1] A.P. Mosk et al., "Controlling waves in space and time for imaging and focusing in complex media", Nature Photonics 6, 283 (2012).
[2] O. Katz et al., "Looking around corners and through thin turbid layers in real time with scattered incoherent light", Nature Photonics 6, 549 (2012).
[3] O.Katz et al., "Noninvasive nonlinear focusing and imaging through strongly scattering turbid layers", Optica, 1, 3, 170-174 (2014).
[4] T. Chaigne et al. "Controlling light in scattering media noninvasively using the photo-acoustic transmission-matrix.", Nature Photonics 8, 58 (2014).
[5] E.Hojman et al. "Photoacoustic imaging beyond the acoustic diffraction-limit with dynamic speckle illumination and sparse joint support recovery", Optics Express Vol. 25, Issue 5, pp. 4875-4886 (2017)
[6] T. Chaigne et al. "Super-resolution photoacoustic imaging via flow-induced absorption fluctuations", Optica Vol. 4, Issue 11, pp. 1397-1404 (2017)
[7] O. Katz et al. " Controlling light in complex media beyond the acoustic diffraction-limit using the acousto-optic transmission matrix", Nature Communications (2019)
[8] D. Doktofsky et al. "Acousto-optic tomography beyond the acoustic diffraction-limit using speckle decorrelation", *Communication Physics* (2020).
[9] O. Katz et al., "Non-invasive single-shot imaging through scattering layers and around corners via speckle correlations", Nature Photonics, 8, 784–790 (2014)
[10] A.Porat et al., "Widefield lensless imaging through a fiber bundle via speckle-correlations", Optics Express (2016)
[11] U.Weiss et al., "Two-photon lensless micro-endoscopy with in-situ wavefront correction" Optics Express Vol. 26, Issue 22, pp. 28808-28817 (2018).