TEMPIX: WIDE-FIELD IMAGING THROUGH SCATTERING MEDIA

Adrià Escobet-Montalbán1,4, Roman Spesyvtsev1,4, Mingzhou Chen1, Wardiya Afshar Saber2, Melissa Andrews3, C. Simon Herrington4, Michael Mazilu1 & Kishan Dholakia1

1 SUPA, School of Physics and Astronomy, University of St Andrews, KY16 9SS, UK
2 School of Medicine, University of St Andrews, KY16 9FT, UK
3 Biological Sciences, University of Southampton, SO17 1BJ, UK
4 CRUK Edinburgh Centre, The University of Edinburgh, EH4 2XR, UK

† Present address: SUPA, Department of Physics, University of Strathclyde, G4 0NG, UK
* E-mail: aem23@st-andrews.ac.uk

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Optical approaches to fluorescent, spectroscopic and morphological imaging have made exceptional advances in the last decade. Super-resolution and wide-field low photo-toxicity imaging are now underpinning major advances across the biological and medical sciences. Whilst the advances have been startling, the key unmet challenge to date in all optical imaging is to penetrate deeper. Here we present TEMPIX as an approach to address this challenge. It uses a judicious combination of temporal focusing [1] with single-pixel detection [2] to obtain wide-field images within or through biological tissue without aberration correction or characterization of the turbid medium.

The outstanding ability of temporal focusing beams to maintain their profile as they propagate through a scattering medium [3] is used to project orthonormal light patterns (in a Hadamard basis) onto fluorescent samples located inside or behind a turbid medium. Fluorescent light emitted by the sample is collected in an epi-fluorescence configuration and the total intensity is measured in a single-pixel detection scheme. As there is no need to have any spatial resolution in the imaging system, TEMPIX tolerates ‘scrambling’ of emitted light achieving remarkable imaging depths. In addition, photo-damage is substantially lower than in point-scanning microscopy techniques since the illumination power is distributed over a large FOV. We demonstrate the effectiveness and potential of TEMPIX by imaging a fluorescent microstructure through rat brain slices of hundreds of microns in thickness reaching a maximum imaging depth of about 7 scattering mean free path lengths (Fig. 1). We show that TEMPIX works well under typical biological research conditions by obtaining images of fluorescent beads and human embryonic kidney cells through unfixed human colon tissue.

Figure 1: Hidden fluorescent microstructure (a) and retrieved images through 200 μm (b) and 400 μm (c) thick slices of fixed rat brain.