Marginal blind deconvolution of adaptive-optics corrected images : first applications to experimental retinal images.

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Purpose

Adaptive Optics corrected flood imaging of the retina is now a well-developed technique [1]. Yet, raw images usually have a low contrast because they are dominated by an important background, and because AO correction is only partial. This makes the interpretation of such images difficult or even impossible without post-processing of the images, which typically combines background subtraction and image deconvolution. Image deconvolution is difficult both because the PSF is usually not well-known (blind or myopic deconvolution) and because the image contains both in-focus and out-of-focus planes of the object under investigation. In this communication we tackle the blind deconvolution problem.

Methods

We model the 3D imaging by assuming that the object (i.e. the photoreceptors) is approximately the same in all planes within the depth of focus. The 3D model becomes a 2D model with the global PSF being a linear combination of the PSFs for each plane. We must estimate the PSF coefficients of this linear combination and the object. We show that the traditional method of joint estimation [2] (Joint MAP) fails even for a small number of PSF coefficients. We derive a marginal estimation of unknown hyper-parameters (PSF coefficients + object PSD + noise PSD) followed by a MAP estimation of the unknown object. Such a marginal estimation is known to have better statistical convergence properties [3], and allows us to obtain a so-called "unsupervised" estimate of the object, i.e. without any parameter to adjust empirically

Results

We show on simulated data the efficiency of this marginal estimation. We have checked that the appealing theoretical property of the marginal estimator of consistency holds in practice: the estimated PSF converges towards the true value of the PSF both when the noise level goes down, and, for a given noise level, when the image size becomes larger.

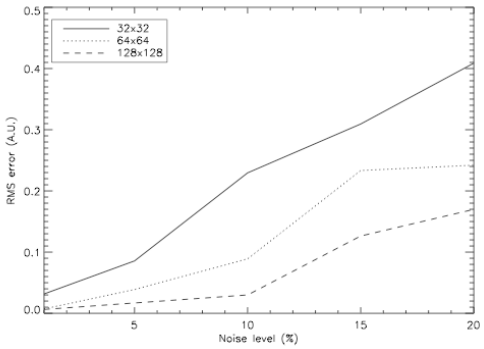

Figure 1 : RMS error of the PSF estimation vs noise and size data

We present promising results on experimental adaptive optics corrected retina images showing a clear improvement in image quality.

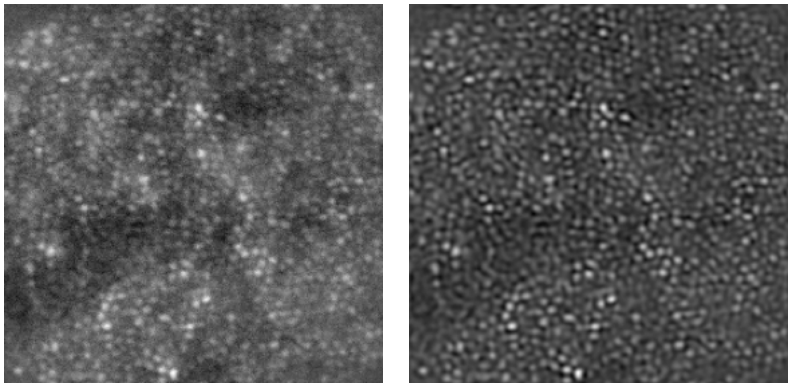

Figure 2 : Left : Experimental image. Right : Deconvolved image

References

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3. A. Blanc, L.M. Mugnier, J. Idier, “Marginal estimation of aberrations and image restoration by use of phase diversity”. J.Opt.Soc.Am A **20(6)**,1035-1045 (2003)