MARKOV RANDOM FIELD AIDED IMAGE RESTORATION IN CONFOCAL AND TWO-PHOTON EXCITATION MICROSCOPY

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Confocal laser scanning (CLS) and two-photon excitation (TPE) microscopy are powerful techniques for 3D imaging of biological samples. Although CLS and TPE microscopy images are better than standard epifluorescence images, they still undergo degradation due to blurring and noise because of the inherent nature of the physical phenomenon (diffraction and photon counting noise) involved. The aim is to obtain the real object from the degraded noisy image. This problem belongs to inverse problems and is found to be very notorious in nature. Several algorithms such as maximum likelihood (ML) based algorithm, have been proposed to reduce these artifacts. Unfortunately, ML based algorithm tends to generate noise artifacts, so regularization constraints based on some prior knowledge have to be integrated to stabilize the solution. This is termed as maximum a-posteriori (MAP) technique. We propose a MAP approach in which the image field is suitably modeled as Markov random field (MRF), forcing the image distribution to be Gibbs distribution. The prior knowledge is incorporated through the potential function in the Gibbs distribution. We proposed potential functions based on white-noise prior, smoothest prior and fuzzy-logic [1][2]. MAP approach has the advantage of include the available prior knowledge in the restoration procedure. In other words, inclusion of prior knowledge makes the notorious inverse problem well-posed.
Various evaluations such as visual inspection and Csiszàr I-divergence are performed on the CLS microscopy restored images to study the characteristics of the proposed approach (in both simulated and real data). It is observed that the noise artifacts are considerably reduced and the desired images characteristics (edges and minute features as islets) are retained in the restored images. The proposed algorithm is found to perform better than existing image restoration algorithm in microscopy. The algorithm is stable, robust and tolerant at various SNR. The convergence of the proposed algorithm is empirically observed. We hope that the proposed algorithm will find wide applications in microscopy and biomedical imaging.

[1] G. Vicidomini, P. P. Mondal, and A. Diaspro, "Fuzzy logic and maximum a posteriori-based image restoration for confocal microscopy," *Optics Letters*, **31**, 3582-3584 (2006).
[2] P. P. Mondal and K. Rajan "Fuzzy-rule-based image reconstruction for positron emission tomography," *Journal of Optical Society of America A*, **22**, 1763-1771 (2005).