EM-TV Reconstruction for Data with Poisson Statistics

THU/P2
16:00–16:20

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This talk deals with reconstruction of density images from raw data with bad Poisson statistics (low count rates), e.g. in the case of medical or nanoscopic imaging. In these cases standard reconstruction methods (OSEM, EM, filtered backprojection) deliver unsatisfactory and noisy results. In our approach, we propose to introduce nonlinear variational methods into the reconstruction process to make an efficient use of a priori information, such as well-separated homogeneous structures. Our technique is motivated by and applied to cardiac positron emission tomography [1] and STED/4Pi microscopy [2].

An interesting approach for the improvement of the reconstruction is the EM-TV algorithm. In classical EM [3], the negative log-likelihood functional is minimized, fitting data with Poisson distributed noise. In EM-TV, that functional is modified, adding a weighted total variation (TV) [4] term. In effect, in the minimization, images with smaller total variation are preferred.

Our approach treats TV without smoothing approximation and realizes cartoon reconstructions, in which noise is suppressed effectively while sharp edges are maintained. The algorithm is implemented by a nested iteration [5]. The first step corresponds to a classical EM step. The second step (TV step) solves a nonlinear and non-differentiable variational problem, which is solved by use of duality [6]. Overall, this yields a robust scheme for penalized EM reconstructions.

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[2] S. HELL, A. SCHÖNLE, A. VAN DEN BOS: Nanoscale Resolution in Far-Field Fluorescence Microscopy. In: *Science of Microscopy* (P.W. Hawkes, J.C.H. Spence, eds). Springer, 2006, pp. 790–834.

[3] L.A. SHEPP, Y. VARDI: Maximum Likelihood Reconstruction for Emission Tomography. *IEEE Transactions on Medical Imaging* **1** (1982), 113–122.

[4] L.I. RUDIN, S. OSHER, E. FATEMI: Nonlinear Total Variation Based Noise Removal Algorithms. *Physica D* **60** (1992), 259–268.

[5] A. SAWATZKY ET AL.: Accurate EM-TV Algorithm in PET with Low SNR. In: *IEEE Nuclear Science Symposium Conference Record*, 2008.

[6] A. CHAMBOLLE: An Algorithm for Total Variation Minimization and Applications. *Journal of Mathematical Imaging and Vision* **20** (2004), 89–97.