New Parameter Choice Rules for Regularization with Mixed Gaussian and Poisson Noise

Elias S. Helou[1] and Álvaro R. De Pierro[2]

Poisson data occurs frequently in photon counting processes, such as photon detection by CCD sensors or emission tomography scanners, sometimes combined with Gaussian white noise. Furthermore, reconstruction or recovery of the emitting objects or regions are often ill-posed inverse problems. Therefore some regularization is required.

For example, it is very common for such problems to be solved by means of optimization models of the form $\min_{\boldsymbol{x}\in\mathcal{C}} \{f(A\boldsymbol{x}, \boldsymbol{b}) + \gamma r(\boldsymbol{x})\}$, f measuring consistency and r containing "prior" infromation. This approach dates back to the seminal Tikhonov regularization method and remains mainstream today. Such models, as every regularization procedure, require the choice of a parameter γ, which controls how much smoothness is imposed on the solution.

In the present work we propose and analyze a new rule for choosing this parameter when measurements are corrupted simultaneously by Poisson and Gaussian noise. The method is based on an estimator for the average divergence between the regularized and the true solution. It is obtained through the well known momenta of the Poisson and Gaussian errors, coupled with a stochastic differentiation scheme to compute the trace of a Jacobian.

The method we present is more flexible than its existing counterparts, though may require more computations. We exhibit numerical experiments related to tomographic image reconstruction in order to substantiate the theoretical analysis.

[1]University of São Paulo, elias@icmc.usp.br
[2]University of Campinas