

ETSIP014 A Bayesian framework for the analog reconstruction of kymographs from fluorescence microscopy data

Abstract

Kymographs are widely used to represent and analyse spatio-temporal dynamics of fluorescence markers along curvilinear biological compartments. These objects have a singular geometry, thus kymograph reconstruction is inherently an analog image processing task. However, the existing approaches are essentially digital: the kymograph photometry is sampled directly from the time-lapse images. As a result, such kymographs rely on raw image data that suffer from the degradations entailed by the image formation process and the spatio-temporal resolution of the imaging setup. In this work, we address these limitations and introduce a well-grounded Bayesian framework for the analog reconstruction of kymographs. To handle the movement of the object, we introduce an intrinsic description of kymographs using differential geometry: a kymograph is a photometry defined on a parameter space that is embedded in physical space by a time-varying map that follows the object geometry. We model the kymograph photometry as a Lévy innovation process, a flexible class of non-parametric signal priors. We account for the image formation process using the virtual microscope framework. We formulate a computationally tractable representation of the associated maximum a posteriori problem and solve it using a class of efficient and modular algorithms based on the alternating split Bregman. We assess the performance of our Bayesian framework on synthetic data and apply it to reconstruct the fluorescence dynamics along microtubules in vivo in the budding yeast *S. cerevisiae*. We demonstrate that our framework allows revealing patterns from single time-lapse data that are invisible on standard digital kymographs.

Index Terms- Quantitative fluorescence microscopy, modelbased image processing, Bayesian modelling, alternating split Bregman, Lévy innovation processes, virtual microscope frame work.



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