Efficient Markov Chain Monte Carlo Samplers for Bayesian Image Analysis

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Many image processing tasks can be formulated in a probabilistic framework. In particular, the Bayesian approach provides a powerful and generic modeling tool for a wide range of inverse problems in image analysis. In this context, we are given a set of observed image properties (like the color of pixels) and from these observations, we want to infer some higher level properties of the image (like a segmentation, 3D depth, etc..) that are hidden. Such an inverse problem can then be treated as a probabilistic inference of the hidden entities from the observations. Once a probabilistic model is constructed, we are given an optimization problem where one has to find the most likely settings of the hidden variables. However, due to the high complexity of the underlying probability measure, gradient-based optimization techniques cannot be applied. Therefore such problems are often solved using Markov Chain Monte Carlo (MCMC) methods. Although the general theory and methodology of these algorithms are fairly standard, they have their limitations in case of image processing problems (dependence of neighboring pixels or varying dimension of model parameters, to name a few). Hence the construction of such samplers, possibly tailored to a particular probabilistic image model, remains a challenge.

Specific aims of the proposed work
- Study a novel probabilistic image model
- Develop an MCMC method which can generate samples from the image model. This sampler will be used to solve the optimization problem.
- Analyze the convergence properties of the algorithm.
- Apply the algorithm to a practical problem, such as automatic segmentation of images, or automatic detection of objects represented by a template shape.

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