Probabilistic image reconstruction for radio interferometers

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We present a novel, general-purpose method for deconvolving and denoising images from gridded radio interferometric visibilities using Bayesian inference based on a Gaussian process model. The method automatically takes into account incomplete coverage of the uv-plane and mode coupling due to the beam. Our method uses Gibbs sampling to efficiently explore the full posterior distribution of the underlying signal image given the data. We use a set of widely diverse mock images with a realistic interferometer setup and level of noise to assess the method. Compared to results from a proxy for the `CLEAN` method we find that in terms of RMS error and signal-to-noise ratio our approach performs better than traditional deconvolution techniques, regardless of the structure of the source image in our test suite. Our implementation scales as $\mathcal{O}(n_p \log n_p)$, provides full statistical and uncertainty information of the reconstructed image, requires no supervision, and provides a robust, consistent framework for incorporating noise and parameter marginalizations and foreground removal.