Bayesian approach of the parameter inverse problem under uncertainties

Victor Trappler

Directeurs de Thèse : Arthur VIDARD (Inria)
Élise ARNAUD (UGA)
Laurent DEBREU (Inria)

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1 (Joint) Posterior formulation

1.1 Priors

$$\begin{aligned} K &\sim \mathcal{U}(\mathbb{K}), \quad p(k) \\ U &\sim \mathcal{U}(\mathbb{U}), \quad p(u) \end{aligned}$$

1.2 Likelihood model

$$\begin{aligned} p(y \mid k, u, \sigma^2) &= \frac{1}{\sqrt{2\pi}\sigma} \exp\left[-\frac{1}{2\sigma^2} SS(k,u)\right] \\ &= \frac{1}{\sqrt{2\pi}\sigma} \exp\left[-\frac{1}{2\sigma^2} \|\mathcal{M}(k,u) - y\|_{\Sigma}^2\right] \end{aligned}$$

Now to Bayes' theorem

$$p(k, u \mid y, \sigma^2) = \frac{p(y \mid k, u, \sigma^2) p(k,u)}{\iint_{\mathbb{K}\times\mathbb{U}} p(y \mid k, u, \sigma^2) p(k,u) \,\mathrm{d}(k,u)}$$

Let us assume an hyperprior for $\sigma^2 : p(\sigma^2)$

$$p(k, u \mid y) = \int p(k, u, \sigma^2) \, \mathrm{d}(\sigma^2)$$