Online Bayesian inference for the detection and monitoring of hazardous events in drilling operations

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Problem Definition

We would like to detect and characterise in real-time washout and mud losses in a motor drilling operation.

- Detection: identify occurrence of washout or mud loss.
- Characterisation: Estimation of unknown states and parameters related to washout or mud loss
- Online ("as observations arrive") and the closest to the occurrence time
- Bayesian inference to handle and quantify uncertainty

State Space Model

We'll define a Dynamical Model for $t = 0, 1, \ldots$ as follows

$$\theta_0 \sim \pi(\theta_0), \tag{1}$$

together with a pair of equations for each time $t \geq 1$,

$$Y_t = f_t(\theta_t) + v_t, \tag{2}$$

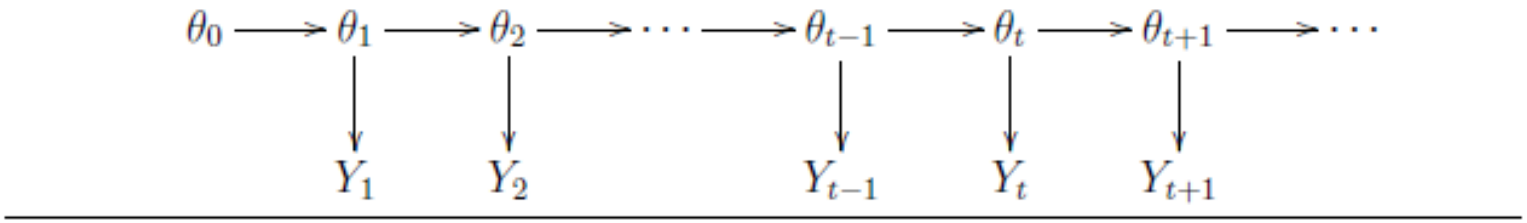
which is called the observation equation and

$$\theta_t = g_t(\theta_{t-1}) + w_t, \tag{3}$$

that is called state equation. Where f_t and g_t are (non-linear) functions and v_t and g_t are two independent random variables with a given distribution.

Estimation

Dependence structure for a state space model.



Complex problems involve non-Gaussian assumptions and non linearity, hence Sequential Monte Carlo provide an approach to compute posterior distributions.

In our case

$$\theta = (\alpha_1, \alpha_2, \beta_2, \omega, K, t_{wash}, z_{wash}) \tag{4}$$

and f_t describes the PDE model. In reality, this is an approximation and we would like to study the influence of the approximation error, and potentially use multilevel Monte Carlo approach