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# Joint Bayesian nonparametric reconstruction of dynamical equations

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We propose a Bayesian nonparametric mixture model for the joint full reconstruction of $m$ dynamical equations,
given $m$ observed dynamically-noisy-corrupted chaotic time series. The method of reconstruction is based on the Pairwise Dependent Geometric Stick Breaking Processes mixture priors (PDGSBP) first proposed by Hatjispyros et al. (2017). We assume that
each set of dynamical equations has a deterministic part with a known functional form i.e.
$\mathrm{x}_{ji} = g_j(\vartheta_j, x_{j,i-1}, \ldots, x_{j,i-l_j}) + \epsilon_{x_{ji}},\ 1 \le j \le m,\ 1 \le i \le n_j. under the assumption that the noise processes (\epsilon_{x_{ji}})$
are independent and identically distributed for all $j$ and $i$ from some unknown zero mean process $f_j(\cdot)$. Additionally, we assume that a-priori we have the knowledge that the processes $(\epsilon_{x_{ji}})$ for $j = 1, \ldots, m$ have common characteristics, e.g. they may have common variances or even have similar tail behavior etc. For a full reconstruction, we would like to jointly estimate the following quantities $(\vartheta_j) \in \Theta \subseteq calR^{k_j}, \quad (x_{j,0}, \ldots, x_{j,l_j-1}) \in calX_j \subseteq calR^{l_j}, and perform density estimation to the \mathrm{m} noise components (\mathrm{f}_j)$.

Our contention is that whenever there is at least one sufficiently large data set, using carefully selected informative borrowing-of-strength-prior-specifications we are able to reconstruct those dynamical processes that are responsible for the generation of time series with small sample sizes; namely sample sizes that are inadequate for an independent reconstruction. We illustrate the joint estimation process for the case $m = 2$, when the two time series are coming from a quadratic and a cubic
stochastic process of lag one and the noise processes are zero mean normal mixtures with common components.

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