

STATISTICS COLLOQUIUM

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“Fast Analysis of Dynamic Systems via Gaussian Emulator”

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ABSTRACT

Dynamic systems are used in modeling diverse behaviors in a wide variety of sciences and engineering. They are often described by a set of linear or nonlinear differential equations. Although the form of the differential equations is usually known, parameters in the differential equations are often unknown. Current methods for estimating parameters in dynamic systems from noisy data are computationally intensive and rely heavily on the numerical solutions of underlying differential equations.

We propose a new Bayesian scheme, which creates an artificial system driven by a Gaussian process to approximate the dynamic system. We introduce an auxiliary variable that connects this artificial Gaussian system to the real dynamic system and further design a sampling scheme enabling our artificial Gaussian system to emulate the real dynamic system as closely as desired. We further impose a hierarchical structure to model the means of different components in our Gaussian system, providing an efficient and accurate estimate of the trajectory of the missing components when dealing with partially observed data. We illustrate this method, named the Gaussian Emulator, by numerical examples ranging from neuroscience to system biology, in both complete and partially observed cases, resulting in a dramatic saving of computational time and fast convergence while still retaining precise estimation accuracy.