Approximate Bayesian Computation and novel Bayesian approaches in cosmostatistics

Report of Contributions

https://indico.math.cnrs.fr/e/CosmoABC

Contribution ID: **1** Type: **not specified**

Bayesian inference with black-box cosmological models

Friday, September 20, 2019 10:15 AM (1 hour)

Large-scale astronomical surveys carry opportunities for testing physical theories about the origin and evolution of the Universe. Advancing the research frontier requires solving challenging and unique statistical problems, to unlock the information content of massive and complex data streams. In this talk, I will present recent methodological advances, aiming at fitting cosmological data with "black-box" numerical models. I will discuss two different solutions, depending on the scenario: Bayesian optimisation (BOLFI) and Taylor-expansion of the simulator (SELFI).

References:
http://arxiv.org/abs/1805.07152
http://arxiv.org/abs/1902.10149

Presenter: Dr LECLERCQ, Florent (Imperial Centre for Inference and Cosmology, London)

Contribution ID: **2** Type: **not specified**

Gibbs-ABC

Friday, September 20, 2019 9:15 AM (1 hour)

Approximate Bayesian computation methods are useful for generative models with intractable likelihoods. These methods are however sensitive to the dimension of the parameter space, requiring exponentially increasing resources as this dimension grows. To tackle this difficulty, we explore a Gibbs version of the ABC approach that runs component-wise approximate Bayesian computation steps aimed at the corresponding conditional posterior distributions, and based on summary statistics of reduced dimensions. While lacking the standard justifications for the Gibbs sampler, the resulting Markov chain is shown to converge in distribution under some partial independence conditions. The associated stationary distribution can further be shown to be close to the true posterior distribution and some hierarchical versions of the proposed mechanism enjoy a closed form limiting distribution. Experiments also demonstrate the gain in efficiency brought by the Gibbs version over the standard solution.

https://arxiv.org/abs/1905.13599

Co-authors: CLARTÉ, Grégoire; STOEHR, Julien; RYDER, Robin

Presenter: Prof. ROBERT, Christian (CEREMADE, Paris)

Contribution ID: **4** Type: **not specified**

ABC in cosmology: Likelihood-free inference without the inverse covariance matrix

Friday, September 20, 2019 2:15 PM (1 hour)

In traditional likelihood-based parameter inference methods, the inverse of the data covariance matrix has to be computed. In cosmology, the covariance is often estimated from expensive numerical simulations. Limits on the allowed biases on parameter constraints from the inversion of the noisy, high-dimensional covariance matrix sets strong requirements on the necessary number of simulations, which has to be much larger than the data dimension. For a realistic setting of typical cosmological data, this number can be in the thousands, making the use of time-consuming N-body simulations prohibitive.

In this talk I propose to use Approximate Bayesian Computation (ABC) as a likelihood-free inference method to obtain constraints on cosmological parameters. Model simulations of the data vector are obtained quickly by drawing from an analytical multi-variate distribution, requiring only a covariance matrix but not its inverse. Using toy models, I show that the number of simulations can be much smaller than the data dimension. I present first results from applying ABC to weak gravitational lensing, which is one of the main cosmological probes to explore dark energy and the dark-matter distribution in the universe.

Presenter: Dr KILBINGER, Martin (CEA Saclay)

Contribution ID: **5** Type: **not specified**

ABC for galaxy star formation history model choice

Friday, September 20, 2019 11:30 AM (45 minutes)

We are interested in the bayesian model choice problem when a large number of objects have to be processed. We propose an extension of the ABC-RandomForest algorithm for model choice, based on crossentropy minimization on the ABC simulation catalogue. This learning algorithm allows us to bypass the use of summary statistics for ABC. We present an application in astrophysics. From photometric data, we show the relevance of the complexification of a stellar formation history model for an important part of the datasets among tens of thousands of galaxies.

Presenter: AUFORT, Grégoire (Institut de Mathématiques de Marseille (I2M) Aix-Marseille Université)