Planet-GLLiM: software for scalable Bayesian analysis of multidimensional data in astrophysics

Stan Borkowski[1], Sylvain Douté*[2], Florence Forbes*[3], and Samuel Heidmann*[4]

[1]INRIA Grenoble – L'Institut National de Recherche en Informatique et e n Automatique (INRIA) – France

[2]Institut de Planétologie et dÁstrophysique de Grenoble – Centre National de la Recherche Scientifique : UMR5274, Université Joseph Fourier - Grenoble 1 : UMR5274 – France

[3]STATIFY team – Univ. Grenoble Alpes, Inria, CNRS, Grenoble INP, LJK, Inria Grenoble Rhone-Alpes, 655 av. de l'Europe, 38335 Montbonnot, France, INRIA Greoble-Rhône Alpes, Univ. Grenoble-Alpes, Laboratoire Jean Kuntzman – France

[4]INRIA Grenoble – L'Institut National de Recherche en Informatique et e n Automatique (INRIA) – France

Résumé

Planet-GLLiM is a software to handle Bayesian inverse problems in the context of physical models inversion in planetary remote sensing. Planet-GLLiM uses Bayesian approximation to inverse physical models given observed data. It is built around a computationally efficient kernel that can easily handle situations where the signals to be inverted present a moderately high number of dimensions and are in large number. The implemented model is based on a tractable inverse regression approach which has the advantage to produce full probability distributions as approximations of the target posterior distributions. In addition to provide confidence indices on the predictions, these distributions allow a better exploration of inverse problems when multiple equivalent solutions exist. These distributions can also be used for further refined predictions using importance sampling, while also providing a way to carry out uncertainty level estimation if necessary. The approach shows interesting capabilities both in terms of computational efficiency and multimodal inference. Planet-GLLiM was specifically tailored to handle inversions of reflectance models given cubes of multi-spectral data and geometries typically produced by planetary remote sensing. The application offers an easy to use graphical user interface and implements the Hapke and the Shkuratof models out of the box. Custom models can be added by the user in the form of a single Python class. Software solving inverse physical problems in astrophysics could be similarly designed using the computational kernel.
Main references :

B. Kugler, F. Forbes, S. Doute. Fast Bayesian Inversion for high dimensional inverse problems. Statistics and Computing, 2021.

S.M. Potin, S. Doute, B. Kugler, F. Forbes. The impact of asteroid shapes and topographies on their reflectance spectroscopy. Icarus, Elsevier, 2021, pp.114806.

*Intervenant