PRISMA Group

optimizAtion Methods and Software for Inverse PRoblems

Image Reconstruction in Astronomy, Medicine and Microscopy

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Borsa della Ricerca

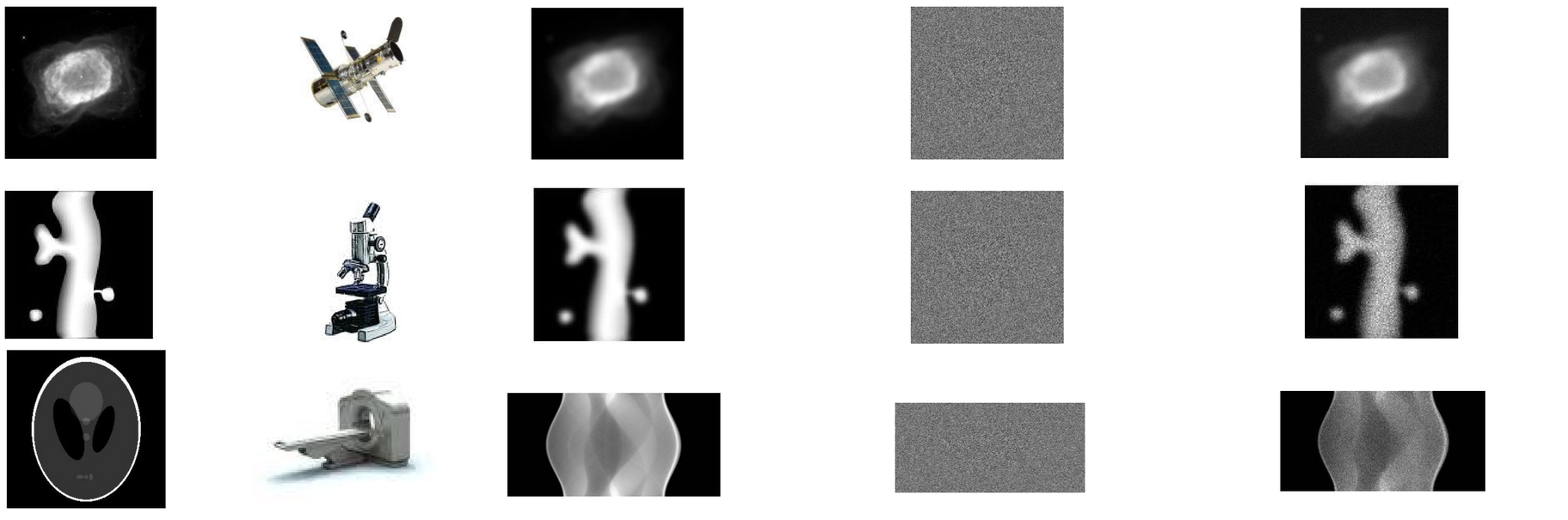
Objective

The aim of the project is to develop image reconstruction methods for applications in microscopy, astronomy and medicine, and to release software especially tailored for the specific application. The image acquisition process produces a degradation of the information with both deterministic and statistical features. For this reason, an image enhancement is needed in order to remove the noise and the blurring effects. The underlying mathematical model belongs to the class of inverse problems, which are very difficult to solve, especially when the specific features of real applications are included in the model. Reliable reconstruction methods have to take into account of the statistics in the image formation process, of several physical constraints and of important features to be preserved in the restored image, as edges and details. The proposed reconstruction methods are based on constrained optimization methods which are well suited for the processing of large size images and also for the 3D case. The research group has a long-term experience in optimization methods for such kind of applications and in the realization of algorithms on parallel and distributed systems, as the GPUs.

Direct and Inverse Problem

Image Acquisition process

Object → **Deterministic** (System response) → **Statistical** (Noise (A/D conversion, photon counting errors, …)) → Data



$\boldsymbol{x}^*$ → $H\boldsymbol{x}^*$ → $\boldsymbol{y} \propto \text{Poisson}(H\boldsymbol{x}^*)$ or $\boldsymbol{y} \propto \mathcal{N}(H\boldsymbol{x}^*, \sigma^2)$

Image Reconstruction

Bayesian Approach

- Maximize the likelihood (fit your data)
- Remove blurring and noise
- Preserve object important features (details, edges, positivity, …)

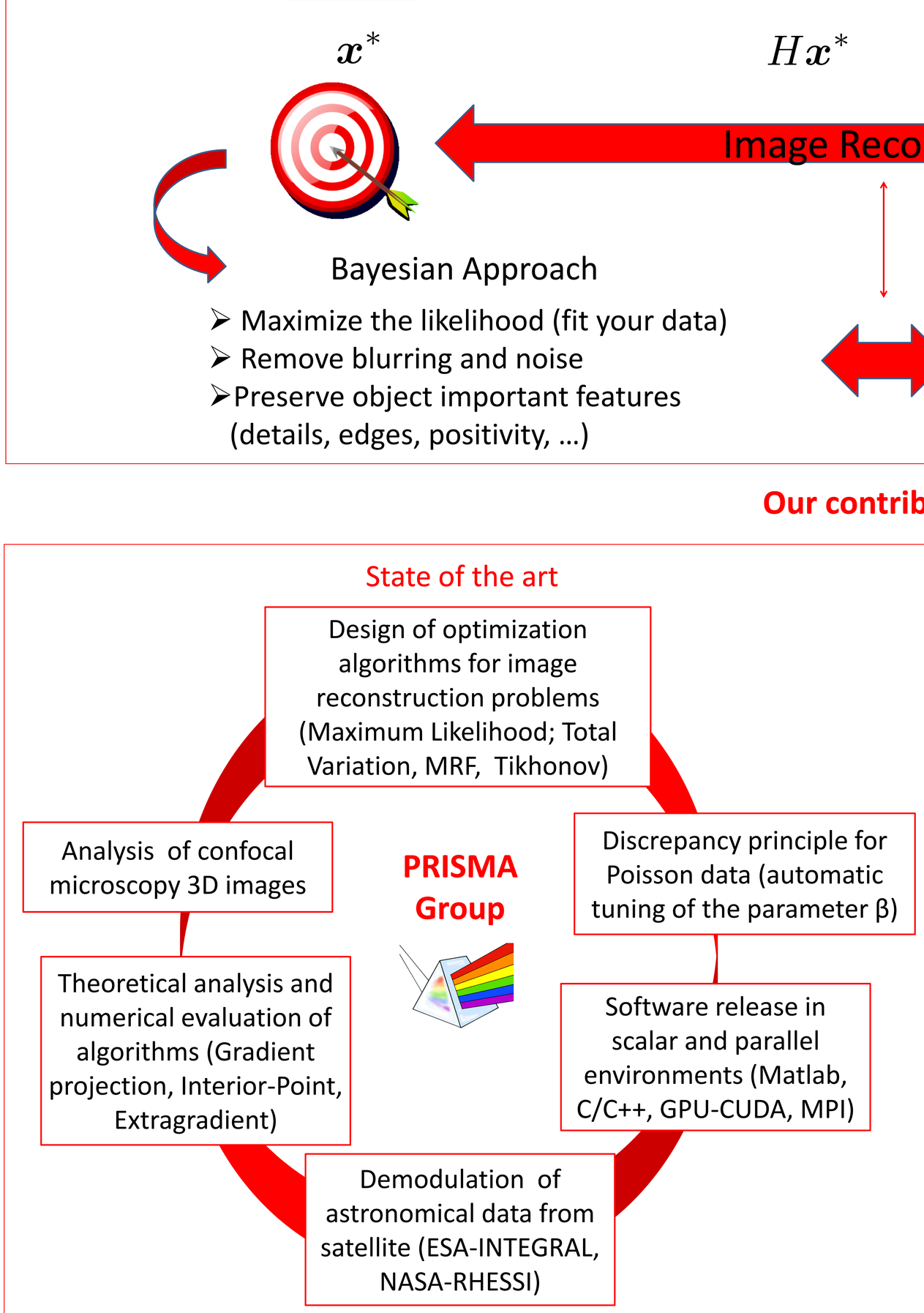
Numerical Optimization

$$\boldsymbol{x}^* \sim \arg\min_{\boldsymbol{x}\in\mathcal{C}} f_\beta^{\boldsymbol{y}}(\boldsymbol{x}) \equiv d(H\boldsymbol{x}, \boldsymbol{y}) + \beta\mathcal{R}(\boldsymbol{x})$$

- Nonlinear, constrained problems
- Large scale

Our contributions

State of the art



Expected results

- Design of image reconstruction methods suitable for the kind of images proposed by the user
- Release of the related prototypical software

Contacts

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