NumPEx

Numérique haute performance pour l'Exascale

Exa-MA annual meeting – january 14-15, 2025

Thematic workshop WP4+WP6

Inverse problems and uncertainty quantification

Applications:

Data assimilation in meteorology, oceanography, climatology

Seismic exploration (Full Waveform Inversion), gravimetry, magnetotellurics, helioseismology, glaciology, etc.

Medical imaging (multimode)

Calibration in Computational Fluid Dynamics

Calibration of neural networks (Bayesian or not)

Issues:

In data assimilation: state dimension (curse of dimensionality !), (initial) state generator, data structure, uncertainty estimation.

In Bayesian inversion: choice of the a priori distribution, sampling of the a posteriori distribution, representation of the a posteriori distribution in high dimension.

Model error estimation and transposition (multi-output problems with measurements limited to a sub-domain or even to some output components).

Real-time 4D imaging.

Related Issues:

Exploiting massive parallelism

Handling massive data, input/output

Visualization (of high-dimensional distribution)

Frugality (multi-fidelity, multiple precisions, etc)

Suggested methodologies:

Global sensitivity analysis

Reduced order models

Derivative-free optimization

ABC methods

Action plan:

- Quantify uncertainties in the results of a high-dimensional inverse problem.
Example: seismic inversion.
With exploratory PEPR Sous-Sol ? With ANDRA (Cigeo) ? CEA (Saclay-Bruyeres) ? Centre of Excellence for Exascale on Solid Earth (ChEESE) ?

- Visualize high-dimensional errors or a posteriori distributions of high-dimensional inverse problems.
With ONERA Toulouse (previsio software) ?
With Julien Tierny (LIP6) ?
With Kitware (developer of Paraview) ?
To be inserted into software such as Croco, Uranie or Openturns (Persalys developed by Phimeca) ?
Suggestion: Postdoc or IR

- **Conclusions:**

- Many issues common to both workpackages.
- Focus on seismic inversion.
- Significant potential industrial applications: how can they be combined?

- Action 1: contact PEPR Sous-Sol, ANDRA, CEA (Saclay-Bruyeres), ChEESE about UQ for seismic inversion.
- Action 2: write a postdoc or IR profile on uncertainty quantification/visualization for high-dimensional inverse problems.