PhD scholarship at Université de Lorraine (Nancy, France): Geomodel updating and transdimensional flow inverse problems

Context

The RING Team is seeking outstanding PhD candidates to address research questions in integrative numerical geology. The PhD topic outlined below, can be tailored to the interests and experience of the successful candidate. This full-time position is for a three-year term and shall start in fall 2020.

The PhD scholarships are sponsored by an international consortium of 12 companies and 139 research institutes. The successful candidates will work in the RING Team[1], a pluridisciplinary group of 12-15 researchers and graduate students working at the interface of geoscience, computer science and applied mathematics. The team is part of *École Nationale Supérieure de Géologie* (ENSG) in the *GeoRessources*[2] laboratory, a research lab of *Université de Lorraine* and CNRS. The research team is driven by passion for developing computer-based methods and theories for geological modeling, serving the geoscience community to address scientific and natural resource managements challenges. It has a strong industry partnership culture.

The PhD candidate will also collaborate with the *Laboratoire de Géologie*[3] of *Ecole Normale Supérieure de Lyon*.

PhD duration is three years, and includes teaching opportunities at ENSG.

Location: Nancy, France. Nancy is a UNESCO World Heritage city with a vibrant student life and a rich cultural agenda, only 90 minutes away from Paris, Luxembourg and Strasbourg. Research visits to Lyon will also be planned during the PhD.

Candidate profile

The ideal candidate is strongly motivated by the topic, passionate about science, has a solid background in applied mathematics, statistics and physics, and has good scientific writing skills. **A proven experience and taste for computer programming is required**. A background or interest in geoscience is appreciated, but not mandatory.

Candidates should hold a MSc in Geophysics or Physics, Computer Science, Geostatistics, (quantitative) Earth Sciences, Porous Media, Applied Mathematics, Engineering or related fields.

A strong command of English language is required. French language is preferable, but not necessary.

How to apply:

Application files must be sent to jobs@ring-team.org before July 19th and must include:

- A cover letter or email,
- A CV, including contact information for two or more referees
- A research outcome (Master's thesis or paper) written by the candidate
- A transcript of grades

Incomplete application files will not be considered.

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[1] http://ring.georessources.univ-lorraine.fr
[2] http://georessources.univ-lorraine.fr/
[3] http://lgltpe.ens-lyon.fr/

Description

Keywords: Inverse problem, Upscaling, Machine learning, Geomodeling, Unstructured meshes.

Advisors: Guillaume Caumon (GeoRessources, Université de Lorraine), Mustapha Zakari (GeoRessources, CNRS), Thomas Bodin (ENS Lyon, CNRS)

Inverse problem theory is a very powerful way to reduce subsurface uncertainty by updating earth model parameters to reflect some new information. Although the theory is very general, its application has mainly been considered globally. A notable exception is the use of adjoint techniques to efficiently identify where model changes will have an impact on a particular physical process. These methods have gained significant popularity in subsurface flow problems (e.g., Ackerer et al., 2014) and in seismology (Fichtner et al., 2006). However, these approaches mainly consider continuous model parameters. In geomodeling, however, some model components are discrete at the scale of concern (e.g., minerals, facies, fractures, layers), hence call for indicator (binary) variables or object-based parameterizations. Then, the number of parameters itself becomes an unknown of the inverse problem. To address this issue, random vector parameterization in conjunction with point processes have been proposed (Cherpeau et al., 2012). Transdimensional inversion (Bodin et al., 2009) has also been considered, and provides a rigorous way to deal with a variable number of model parameters. However, transdimensional methods so far have been applied to relatively simple model parameterizations such as Voronoi diagrams.

The first objective of this PhD is to **consider more suitable geological parameterizations in transdimensional inversion, such as layer boundaries defined by implicit functions, faults and fractures** (Wellmann & Caumon, 2018). For example, one could allow for subdividing or merging geological layers in a stratigraphic domain in a particular transdimensional iteration. Introducing or removing faults could also be considered. To measure the effect of this type of transition, we will consider the physical problem of fluid flow in layered porous media.

The second objective is to assess whether and how to best **exploit the *local* aspect of model updating in transdimensional methods** to reduce the computational burden. For this, a significant focus will be to consider the effect of topological changes in the geomodel by considering **flow-based upscaling methods** (Durlofsky, 2005; Nœtinger et al., 2005). In these approaches, machine learning may be considered to accelerate the exploration of the relationships between model space and data space.

This PhD project is connected to the ongoing PhD thesis of Capucine Legentil (2019-2022), who focuses on the computational geometry challenges of local tetrahedral mesh updating. However, the methodology will first be developed on two-dimensional (2D) models to facilitate prototyping and to minimize the computational costs.

Once the transdimensional approach has been demonstrated on 2D models, three-dimensional applications will be considered, considering for instance sub-seismic faults in the Volve hydrocarbon reservoir (Norwegian North Sea) or the regional geothermal system of Basse-Terre (Guadeloupe).

References

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