Post-doctoral position – Reference: IVA2020

Title: “Inversion Velocity Analysis and associated tomographic Hessian”

Period: Available from January 2020, for 2 years

Contact: Hervé Chauris (herve.chauris@mines-paristech.fr), +33 1 64 69 49 13

http://geophy.geosciences.mines-paristech.fr/

Abstract:

Inversion Velocity Analysis (IVA) is an imaging technique to determine the subsurface structures from seismic measurements at the surface. More precisely, it consists of analysis focusing panels (Common Image Gathers, CIGs) obtained by splitting the velocity model into a macro-model (m_0) and a model perturbation (δm) also known as the reflectivity model. In a given macro-model m_0, the recently developed pseudo-inverses allow to construct quantitative CIGs, i.e. images that can be directly interpreted in terms of velocity perturbations expressed in m/s. The other related advantage of IVA is to have a more robust velocity analysis for the determination of the optimal macro-model.

IVA could be summarised as a bi-level (migration + tomography) approach. In the inner loop, the migration part is efficiently implemented through the application of the inverse. For the outer loop, the objective is to determine an optimal macro-model (tomographic part). Overall, IVA is a computationally and memory-demanding process for the following reasons:

- The scheme relies on the “extended-domain” to evaluate the quality of the image focusing. This has the advantage to guarantee a data fit along the iterations;
- Compared to Full Waveform Inversion (FWI), 4 Green’s functions are involved in the derivation of the gradient of the objective function with respect to the macro-model (instead of two for FWI).

There is a clear need to reduce the number of tomographic iterations (outer loop). For that, the Hessian (second-order derivative of the objective function) plays a fundamental role. IVA is known to have a convex objective function: a Newton approach (that takes into account the Hessian) is a priori well suited in this context. Note that the introduction of the inverse operator in the inner loop, leading to a fast inner-loop convergence, does not guarantee a fast convergence for the outer loop.

We propose the following working programme:

- 3 months: Study of the explicit shape of the Hessian in models with a limited size. The objective is (1) to better determine the main characteristics of the Hessian (e.g. band diagonal matrix, dependency on depth, …) and (2) to determine appropriate preconditioners;
- 6 months: Implementation of the trunctated-Newton approach (a second-order adjoint formulation) to take automatically the effect of the inverse of the Hessian et evaluation of this strategy with respect to the more standard conjugate and quasi-Newton approaches;

- 6 months: Modification of the outer loop objective function to let the tomographic Hessian be more diagonal and closer to the identity operator. In that case, the convergence is automatically accelerated. One possibility is to define a time-domain IVA approach: once the CIGs are built and after the application of the annihilator, it is possible to apply the Born modelling operator to generate synthetic data. The norm of the data would be minimal for the correct macro-model. The shape of the associated Hessian will be modified accordingly. It is interesting to study how a modification of the definition of the objective function could lead to a more suited tomographic Hessian;
- All the previous approaches should be illustrated on 2d synthetic data sets;
- 6 months: Application on a real data set provided by Total and transfer to Total of the new approaches
- 3 months: Intermediate and final reports

The person should have a strong background in maths and physics, as well as good capabilities in scientific programming. He/she should be interested in geophysics and more precisely in seismic imaging. The candidate will be located in MINES ParisTech / ARMINES (Fontainebleau).

How to apply:

Please send to Hervé Chauris (herve.chauris@mines-paristech.fr):

- A resume
- A motivation letter
- A link to the PhD thesis
- The reports of the PhD thesis by the reviewers