Postdoctoral Position

Stochastic Filtering for Surface Evolution Tracking

Application to Salt/Rock Interface Tracking in Geology

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KeyWords

Temporal tracking, Level-Set, Non-linear Stochastic Filtering, Particle Filter, Analog Model, Salt Tectonics

Context

Salt tectonics is a sub-discipline of structural geology that describes the deformation of structures due to the specific behavior of salt. Having a good understanding of the deformation and stress state both within the salt structures and the surrounding rocks is crucial. Indeed, the presence of salt in a basin affects virtually all aspects of the structural system (for example all kinds of subsurface long term storage systems [2, 4])

The objective of this research is to analyze the movement and deformation of the salt/rock interface over time. Since the underlying physical model is often complex and inaccurate, it needs to be supplemented by time dependent observations to correct the model estimation. IFP Énergies nouvelles performed a large number of physically scaled sandbox (analog) experiments using a computed tomography scanner that provides high frequency 3D images. This collection of images mimics the kinematics and structural evolution of complex systems where salt structures are involved. [5, 3].

In order to track the salt/rock interface in these images, the idea is to use a non-linear stochastic filtering algorithm [1] recently developed by the INRIA Fluminance Group. First developed to analyze images from biology and meteorology, this method is promising for salt/rock interface tracking as illustrated on the Fig1. More specifically, this postdoctoral research project has three main objectives:

Your Mission

2D stochastic filtering on cross sections of salt/rock interface images

The INRIA team Fluminance developed a mathematical model that estimates velocities and displacements. In this model, the interface and its evolution is implicitly defined by a level set. At each time step, a N particle filter tries to associate one level set for each particle representing the interface so that the mean level set is the best estimate of the tracked interface at that time.

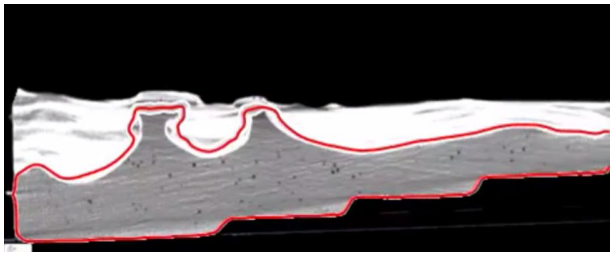

Figure 1: close curve in red that represents salt/rock interface in 2D at one time step

The evolution model established by INRIA team is generic: the first objective of the postdoc will be to get up to speed with the theory and existing source code and adapt it to the case of salt tectonics.

Parallelization strategy and code enhancement

Particle filters are computationally intensive, especially when the state of the particle is an entire 2D image that needs to be estimated at each time step. A parallelization strategy have to be developped by the postdoc that could range from a classical HPC approach on IFPEN's supercomputer ENER440 (8640 cores up to 445 Tflops) to a distributed one on a Hadoop/Yarn cluster.

Extension of dynamic equations to 3D

Once validated on 2D images extracted from 3D image cubes provided by our CT scanner, the theoretical extension of the level set framework is to be investigated. The postdoc should focus on developing evolution models well suited to compute a velocity field and track a 2D surface embedded in a 3D level set.

General Informations

This postdoc is part of a collaboration between INRIA (Institut National de Recherche en Informatique et en Automatique) and IFPEN (Research institute with an international scope in the field of energy, transport and the environment). The postdoc will be located at IFPEN in Rueil-Malmaison (Paris area) and the research will be performed in collaboration with the Fluminance research group in Rennes (Bretagne). We offer a one year contract with a possible extension of 6 months. Remuneration for the postdoc includes a gross salary of 37.5 k€ per year, full access to the French healthcare, social care and pension system, as well as several other benefits, like coverage of 50% of Paris public transport fees.

Qualifications

Candidates should hold a Ph.D. in Computer Science or Applied mathematics (or be near completion), be proficient in English and have excellent programming skills (C++, python). In particular, we look for applicants with experience in image processing and with some stochastic filtering background.

Application, contact

Candidates should send their CV and a short cover letter to Jean-François Lecomte.
(jean-francois.lecomte(at)ifpen.fr)

References

[1] Christophe Avenel, Etienne Mémin, and Patrick Pérez. Stochastic level set dynamics to track closed curves through image data. *Journal of Mathematical Imaging and Vision*, 49(2):296–316, June 2014.

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