Research Centre for Greenhouse Gas Innovation

Lead institution: RCGI/USP	
Supervisor name: Hermes Senger (UFSCar)	**Department:** Computing Department – Federal University of São Carlos (UFSCar) Computer Engineering and Digital Systems Department – University of São Paulo
Recipient: https://sites.usp.br/rcgi/opportunities/ **Ref: 24PhD293 – PhD Scholarship** **Deadline for submission: December 31th, 2024**	**Type:** PhD Scholarship (1 position) **Period:** 40 hours/week **Number of months:** 48 **Intended beginning date:** January, 2025

Project title: (Portuguese and English)

Imagem quantitativa avançada de carbonatos do pré-sal (Caracterização de reservatórios sísmicos utilizando FWI)

Anisotropic ViscoElastic Numerical Inversion Research (AVENIR)

Research theme area: **(Portuguese and English)**

Engenharia de Computação, Ciência da Computação, Computação de Alto Desempenho, Dinâmidca de Fluidos Computacional, Matemática Aplicada, Engenharias, Geofísica

Computer Engineering, Computer Science, High-performance Computing, Computational Fluid Dynamics, Applied Mathematics, Engineering, Geophysics

Abstract (Portuguese and English)

O candidato irá colaborar com os pesquisadores do projeto AVENIR fomentado pela Total Energies junto ao Research Centre for Gas Innovation da POLI-USP na Universidade de São Paulo. Resumo do programa e os projetos podem ser encontrados no site da RCGI (https://sites.usp.br/rcgi/).

O objetivo geral do projeto de pesquisa é desenvolver algoritmos baseados em elementos finitos e diferenças finitas para resolver com eficiência e precisão problemas diretos e inversos associados à propagação de ondas viscoelásticas em meios anisotrópicos. Os códigos Devito (para diferenças finitas) e spyro (para elementos finitos) serão empregados como pontos de partida neste trabalho, de modo que os produtos do projeto de pesquisa se beneficiarão e herdarão o alto desempenho, portabilidade e flexibilidade dessas bibliotecas. Os códigos devem poder rodar em arquiteturas de CPU e GPGPU.

De forma mais específica, o(a) estudante bolsista desenvolverá a sua pesquisa no desenvolvimento de algoritmos de imageamento sísmico e de estratégias de computação de alto desempenho para a melhoria de desempenho dos algoritmos em clusters de HPC com CPUs e GPUs.

The candidate will collaborate with researchers from the project MitDev promoted by Total Energies at the Research Centre for Gas Innovation of POLI-USP at the University of São Paulo. Summary of the program and projects can be found at the RCGI website (https://sites.usp.br/rcgi/).

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The objective of the project AVENIR– Anisotropic ViscoElastic Seismic Imaging – is to build highly efficient, domain-specific language software tools to perform full waveform inversion (FWI) based on three-dimensional, tilted transverse isotropic (TTI) viscoelastic wave modelling. To achieve this goal, the team will first work on the construction of three-dimensional viscoelastic TTI kernels to be run efficiently in GPGPU hardware. Next, aspects related to accuracy and performance improvement will be tackled, namely the implementation of absorbing boundary conditions, correct representation of source injection and receivers, optimized spatial and time discretization schemes, and mimetic coupling between elastic and acoustic solvers. Next, the seismic imaging inverse problem will be dealt with by developing optimization algorithms, automating the calculation of gradients and devising robust techniques for multiparameter inversion and target oriented imaging. The project will be developed in three branches: Branch A will explore finite-differences discretization using the software Devito, Branch B will focus on high order finite-element discretization using the software spyro, and Branch C will be devoted to the development of robust elastic FWI algorithms. Branches A and B will be developed in two phases: Phase 1 will be dedicated to the construction of the numerical models for accurate and efficient forward propagation, and in Phase 2 the team will build FWI algorithms, incorporating the developments of Branch C into Devito and spyro. Key aspects that will permeate the entire development chain are abstraction, automatization, layering, flexibility, portability, performance, and integration.

More specifically, the PhD student will carry out his/her research in the development of seismic imaging algorithms based on the finite difference method and their optimization for HPC clusters equipped with GPUs.

Description (Portuguese and English)

O candidato contribuirá alinhado aos principais objetivos do projeto:

1. Implementação de propagadores de ondas acústicas elásticas e visco-elásticas com anisotropia utilizando tecnologias de compilação e linguagens específicas de domínio
2. Desenvolver técnicas de compilação e otimização de código baseado no método de diferenças finitas para clusters de HPC dotados de CPUs e GPUs
3. Projetar e implementar estratégias de aceleração e otimização de código dos algoritmos desenvolvidos para clusters de HPC com CPUs e GPUs.

The applicant will contribute in line with the main objectives of the project:

1. Implementation of anisotropic elastic and viscoelastic wave propagators using DSLs (Domain Specific Languages) such as Devito.
2. Develop compiler technologies for the optimization of finite difference kernels for high-performance computing (HPC) architectures based on CPUs and GPUs.
3. Design and implement HPC strategies for code optimization and acceleration of the algorithms on HPC clusters with CPUs and GPUs.

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Requirements to fill the position. (Ex: specific experience, minimum or maximum years after concluding the course) (Portuguese and English)

Este projeto é adequado para um(a) candidato(a) altamente motivado(a) e requer habilidades de programação e conhecimentos de métodos numéricos. O(A) candidato(a) deve ter formação de nível superior em engenharia, computação, matemática, física ou geofísica. Conhecimento em inglês é necessário. Experiência na elaboração de métodos e ferramentas de computação de alto desempenho, computação em nuvem ou otimização de código serão considerados diferenciais.

This project is suitable for a highly motivated candidate and requires programming skills and knowledge on numerical methods. The candidate must have a university degree in engineering, computing, mathematics, physics or geophysics. Knowledge of English is required. Experience in the development of either high-performance computing, cloud computing, or code optimization is a differential.

Funding Notes: This Phd scholarship is funded by FUSP. The scholarship will cover a standard maintenance stipend of R$ 5.000,00 per month.

Work place: Departamento de Computação - Universidade Federal de São Carlos (DC/UFSCar) Rod. Washington Luis km 235 SN, São Carlos – SP, Brazil
or
Escola Politécnica de São Paulo (Polytechnic School of the University of São Paulo) Av. Prof. Mello Moraes, 2603 - São Paulo – SP, 05508-030

Documents/Information to be Sent:
Ref: 24PhD293

1) Access the link https://sites.usp.br/rcgi/opportunities/
2) Find the Position Ref: 24PhD293
3) Click on Application to apply

Deadline: December 31th, 2024

In case you have any question, please write to rcgi.opportunities@usp.br