

**JOB OFFER – STAGE**  
**Machine learning optimization of multigrid solvers.**

**OFFER INFORMATION**

**Reference:** ALGO-2025-CK-01  
**Team:** ALGO

**Location:** 42 Avenue Gaspard Coriolis – 31057 Toulouse

**Supervisors:**

- Carola Kruse
- Paul Mycek
- Luc Giraud

**Gratification:** 700€ net per month - M2 level or last year at engineering school

**Period:** 6 months - from: 06/01/2025

**Key words:** PDE solvers, multigrid, machine learning, optimization

**CERFACS**

Cerfacs is a private research, development, transfer and training center for modeling, simulation and high-performance computing. Cerfacs designs, develops and proposes innovative software methods and solutions to meet the needs of its partners in the aeronautics, space, climate, environment and energy sectors. Cerfacs trains students, researchers and engineers in simulation and high-performance computing.

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**HOSTING TEAM - ALGO**

The Algo team conducts research in the fundamentals of high-performance simulation. This includes a wide range of topics in applied mathematics, such as scalable algorithms in numerical linear algebra, iterative and direct algorithms for large linear systems, novel methods for solving partial differential equations, data assimilation, optimization, uncertainty quantification and scientific machine learning.

**CONTEXT**

Multigrid algorithms are extremely efficient for solving elliptic partial differential equations (PDEs), especially on Cartesian meshes. However, their convergence may deteriorate on more complex meshes, and may not be guaranteed for certain classes of PDEs. On the other hand, machine learning techniques have proven to be a powerful tool for generalization, but their computational cost is still higher than multigrid methods, for a worse accuracy. At Cerfacs, we propose a hybrid method in which certain ingredients of the multigrid algorithm can be learnt. In this way, we aim to design optimal multigrid algorithms for target classes of PDEs and meshes.

## MISSION

You will contribute to the development of the EvoStencils code, specialized in the optimization of multigrid algorithms. Initially, you will use the available tests/scripts and scientific publications to get familiar with the subject. Then, you will investigate the optimization of the stencils that define the smoothing, restriction and prolongation operators for the 2D Poisson equation on Cartesian meshes. Depending on the conclusions of these experiments, you will then consider a 3D setting and/or more complex meshes and/or other PDEs, such as the Helmholtz equation. The aim is to interpret the results and provide guidelines on how to design the multigrid algorithm to be optimal for a particular setting. With your results and observations, you will participate in the writing of a publication, in the form of a technical report, journal article or conference paper.

## DESIRED PROFILE

- You are a Master 2 or last-year engineering student,
- Required skills:
  - You have strong skills in applied mathematics and machine learning,
  - You have experience with Python and git,
- Desired skills:
  - You have experience in numerical linear algebra,
  - You are fluent in spoken and written English.

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## HOW TO APPLY ?

To apply, please send your CV and covering letter to [kruse@cerfacs.fr](mailto:kruse@cerfacs.fr) , applications are open until 17/01/2025.

See you soon at CERFACS!