Internship / Ph.D. thesis
(master 2 or 3rd year level of engineering school)
Inria Paris

Context: Inria Paris project-team SERENA

Subject: Parallel adaptive hp FEM

Contents of the Ph.D. thesis

Adaptive finite element methods are proven to be the most efficient numerical approach for approximation of partial differential equations [1,2]. This master's internship aims at addressing two key points associated with hp adaptive finite elements: linear solvers for large sparse systems of algebraic equations and a posteriori estimates on the error between the available numerical approximation and unknown exact solution. It is known from [3] and the references therein how to design a multigrid solver with the number of iterations independent from the mesh-size parameter \( h \) and the polynomial degree \( p \). Similarly, a posteriori error estimates with quality independent from both \( h \) and \( p \) are known from [4] and the references therein. Both approaches involve the solution of a local problem on a patch of elements around each mesh vertex. The goals of the internship are:

1. Design, analyze, and implement a parallel version of the hp solver and estimate from respectively [3] and [4]. This is possible since the local problems are mutually independent and thus can be solved independently one from the other.
2. Design, analyze, and implement an improvement of the above approach where the sizes of the linear systems are reduced from a patch of elements to an individual element. This is possible using the theoretical foundations from [3,4].

A prospective Ph.D. thesis following the internship could additionally address:

1. Optimal stopping criteria for the iterative multigrid solver, based on a posteriori error estimates identifying the two error components (algebraic and discretization).
2. Application of the numerical algorithm from this internship to 3D problems, possibly arising from numerical simulation of environmental problems.

The work will be carried out in the SERENA project-team of Inria Paris, in collaboration with the CERMICS laboratory at Ecole des Ponts ParisTech. The project advisors will be Zhaonan Dong (chargé de recherche, Inria Paris) and Martin Vohralík (directeur de recherche, Inria Paris).

References

https://team.inria.fr/serena/
https://project.inria.fr/gatipor/

Candidate profile

Master 2 or 3rd year level of engineering school student with very good level in functional analysis, numerical methods, and programming (Matlab, Julia, C++).

Practicalities

Timing: 6 months, starting spring 2023 (the internship). 3 years, starting autumn 2023 (the prospective Ph.D. thesis). The knowledge of the French language is welcome but by no means compulsory.

Application

To apply, send a CV highlighting your background in numerical analysis, scientific computing, and programming, a list of courses and notes, and a short motivation letter to internship supervisors Zhaonan Dong (zhaonan.dong@inria.fr) and Martin Vohralík (martin.vohralik@inria.fr).

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