Project Team INRIA : **HiePACS**

Author of the post-doctoral research subject : L. Giraud, J. Roman
Title of the post-doctoral research subject :

Iterative solution techniques for linear systems with multiple right-hand sides

Scientific priorities :

Modeling, Simulation and Optimization of Complex Dynamic Systems

Scientific Research context :

In many large scientific and industrial applications, one has to solve a sequence of linear systems with several right-hand sides given simultaneously or in sequence (radar cross section calculation in electromagnetism, various source locations in seismic, parametric studies in general, ...).

For ``simultaneous'' right-hand sides, the solvers of choice have been for years based on matrix factorizations as the factorization is performed once and simple and cheap block forward/backward substitutions are then performed. In order to effectively propose alternative to such solvers, we need to have efficient preconditioned Krylov subspace solvers. In that framework, block Krylov approaches, where the Krylov spaces associated with each right-hand side are shared to enlarge the search space will be considered. They are not only attractive because of this numerical feature (larger search space), but also from an implementation point of view. Their block-structures exhibit nice features with respect to data locality and re-usability that comply with the memory constraint of multicore architectures.

For right-hand sides available one after each other, various strategies that exploit the information available in the sequence of Krylov spaces (e.g. spectral information) will be considered that include for instance technique to perform incremental update of the preconditioner or to built augmented Krylov subspaces.

Post-doctoral researcher work description :

The candidate will primary work on block preconditioned Krylov approaches and numerical techniques suited for the solution of linear systems with multiple right-hand sides. She/he will first review the latest developments on this subject in order to identify what variants are the most promising according to the features of the various applications we are currently looking at in the framework of collaborative actions with physicists. Depending on the progress, the situation where the matrix changes will also be considered in order to investigate what are the possibilities to recycle Krylov space information from one block solver to the next.

The robustness of the design parallel numerical schemes will be assessed on large challenging applications and simulation will be performed on large computing platform.

Required Knowledge and background :

The successful development of the scientific work described above requires a strong background in applied mathematics (to design/adapt numerical schemes) and in computer science (to perform an efficient parallel implementation); therefore a PhD in computational sciences (applied maths and/or computer science) would be ideal.

Former experiences in parallel code development (MPI, muti-threading) and a good knowledge in parallel numerical linear algebra algorithms is a requirement. A strong interest in large numerical simulation would surely be an additional asset.

References :

1. M. H. Gutknecht. Block Krylov Space Methods for Linear Systems With Multiple Right-hand Sides: an Introduction. In Modern Mathematical Models, Methods and Algorithms for Real World Systems (2007), pp. 420–447.
2. R. B. Morgan. Restarted block-GMRES with deflation of eigenvalues. Appl. Numer. Math. 54,

number 2 (2005), 222–236.
3. M. Robbe & M. Sadkane, Exact and inexact break downs in the block GMRES method. Linear Algebra and its Applications,419(1):265–285, 2005.
4. Y. Saad. Iterative Methods for Sparse Linear Systems. SIAM, Philadelphia, 2003. Second edition.
Keywords : Block Krylov solver, deflation techniques, preconditioning/subspace updates.
Duration : 12 months