Scientific Report

by
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in INRIA, France

Duration: 1st July 2005 – 31st March 2006
Scientific Advisor: Dr. Jerome Jaffre

Brief Summary of the research carried out in INRIA, France

The aim of my post doctoral programme in INRIA Rocquencourt, France was to develop an efficient and robust parallel computer code for the simulation of flow and transport in geology related problems. To carry out this work, first we discussed about the necessary tools required for solving such complicated problems which may have very different hydrogeological properties and complex geometries. The problem has been discretized using mixed finite element method. As the realistic three dimensional system is very large in view of computer memory and very much time consuming too, it was decided to use the technique of domain decomposition using nonoverlapping subdomains and suitable parallelization to efficiently use the computer resources. The domain decomposition algorithm has been evolved in such a way that solving the problem is equivalent to solve two sets of problems, which are smaller in size and can take advantage of parallelization. First there is a series of local subdomain problems which can be independently solved on parallel processors. Then there is an interface problem which can be solved iteratively using conjugate gradient algorithm, which is again very much suitable for parallelization. As the domain of the problem under consideration may consist of several subdomains with different hydrological properties, these subdomains will have different space-time scales. In our approach we use different space discretizations with a unique time discretization. This requires subdomains to be discretized independently in space and as a result subdomain meshes are nonconforming

at the interfaces. This brings in the need of using the technique of mortar method on the interfaces. Further for the interface problem, there might be difficulties in terms of getting singular matrices depending upon the prescribed boundary conditions. To overcome all these problems, we use Balancing domain decomposition for mortar mixed finite element methods as proposed by Pencheva and Yotov [1].

The time was devoted to discuss various technical difficulties with the group members, which can arrive while programming all these techniques. After having a clear understanding of the entire algorithm and the necessary tools which will be required subsequently, now we have started programming the entire method. A parallel conjugate algorithm is under development in OCAMLP3L for the iterative simulation of the interface problem and as a next step, we are developing a balancing preconditioner for this problem. On the other hand, we are developing a module for the book keeping of unknowns on the non matching interface meshes to use mortar elements and an appropriate way to generate mortar mesh on the interfaces. The local subdomain solver has been written in LifeV and we need to use the tools of code coupling between LifeV, OcamlP3L and C++ programming language. In view of the long term goals and complexities of the problem, I will continue to work on the same problem during my next post doctoral programme for nine months in FNR Luxembourg. The scientific advisor Dr. Salim Belouettar in FNR, Luxembourg has already given his consent for this project.

List of the publications, conferences and workshops attended during the fellowship

1. Attended the lecture series on “Flow in Unsaturated Porous Media: Mathematical and Numerical Aspects”, 12^{th}-15^{th} Sep., 2005 in INRIA Rocquencourt, France.

2. Participated and presented a paper on “3-D Finite Element Computation on Parallel Processors of the Natural Convection Process in a Porous Enclosure” at the conference on “50^{th} Congress of Indian Society for Theoretical and Applied Mechanics” during 14^{th} -17^{th} Dec., 2005 in Indian Institute of Technology, Kharagpur, India. Paper published in the proceedings of ISTAM, 2005.

3. Abstract titled “Nonconforming meshes for flow and transport in porous media”, accepted for the conference of Computational Methods in Water Resources, XVI International Conference, Copenhagen, Denmark, June 19-22, 2006.

4. Abstract titled “Porous Media Flow Simulation on Non Conforming Meshes with Balancing Domain Decomposition” accepted for 5th International Conference on Scientific Computing and Applications, Banff, Alberta, Canada, May 18-22, 2006.

Reference:

[1] G. Pencheva and Y. Yotov, Balancing decomposition for mortar mixed finite element methods, Numerical Linear Algebra with Applications, vol. 10, pp. 159-180, 2003.