Adapting optimization procedures for the solution of coupled problems

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ABSTRACT

A robust and stable numerical solution for coupled PDE problems has been an active area of research. Though monolithic solution procedures for such problems have proven to be efficient and robust, treatment of the coupled problem in an iterative partitioned approach, using Gauss-Seidel pattern for exchange of data, in order to facilitate black box treatment of specialized solvers for respective PDEs is attractive and of practical importance. This approach together with update schemes like Interface Quasi-Newton schemes [2] and Aitken has shown good behaviour in terms of robustness and stability in a wide range of applications. Though this approach reduces necessary iterations, the Gauss-Seidel pattern of exchange of data between the PDE solvers, which requires the PDEs to be solved one after the other, increases the total execution time for the simulation.

In this work the findings of an investigation of an alternative coupling scheme based on treatment of the coupled problem as an optimization problem are presented [1]. This scheme, uses a Jacobi pattern, thus facilitating the parallel solution of PDEs and thus results in lesser execution time. The theory and implementation of the methodology are established using a small structure-structure problem which has the same governing linear PDE on both domains. For the optimization problem, a scalar objective function is formulated to reduce the difference of the fields on the coupling interface. The initial investigations include testing the scheme with different physical properties for the subsystems which reflect different levels of interactiveness between the subsystems. Figure 1 shows comparison of the scheme with other schemes for two of the tested configurations.

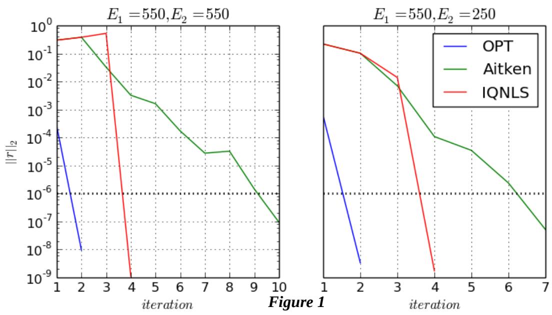

Figure 1

The results of the previous investigation from Figure 1 show that the new update scheme does converge in all the cases it is tested and thus hints a robust convergence behaviour. This shows that when the information necessary for this scheme is available, it is more reliable in terms of robustness. In the next stage, an investigation is made with two subsystems with different governing equations. That is, one domain as a structure and the other with convection diffusion equation. The investigation also uncovers the scenarios where the mentioned schemes can have troubles in convergence. Thus giving a general understanding of the coupled problem itself in terms of what can cause convergence problems. With the promising behaviour observed, formulation of the fluid-structure interaction problem as an optimization problem and applying the described update scheme is done and has shown similar robust behaviour. Extension of this scheme for n-field coupling problem is in progress so as to facilitate parallel execution of the solvers.

REFERENCES

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