A PARALLEL NONLINEAR ADDITIVE SCHWARZ PRECONDITIONED INEXACT NEWTON ALGORITHM FOR INCOMPRESSIBLE NAVIER-STOKES EQUATIONS

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A nonlinear additive Schwarz preconditioned inexact Newton method (ASPIN) was introduced recently by Cai and Keyes [1] for solving large sparse nonlinear systems of equations obtained from the discretization of nonlinear partial differential equations. The method was proved to be more robust than the traditional inexact Newton methods, especially for problems with unbalanced nonlinearities. In this talk, we discuss some recent developments of ASPIN for solving the steady-state incompressible Navier-Stokes equations in the velocity-pressure formulation. The sparse nonlinear system is obtained by using a $Q_1 - Q_1$ Galerkin least squares finite element discretization on two dimensional unstructured meshes. The key idea of ASPIN is that we find the solution of the original system $F(X) = 0$ by solving a nonlinearly preconditioned system $\mathcal{F}(X) = 0$ that has the same solution as the original system, but with more balanced nonlinearities. The nonlinear preconditioners are based on the solution of the Navier-Stokes equations defined on the overlapping subdomains with some proper boundary conditions. In this talk we present some numerical results obtained on parallel computers for two challenging CFD benchmark problems: a driven cavity flow problem and a backward facing step problem. We compare our approach with some inexact Newton method with different choices of forcing terms. The numerical results show that ASPIN is more robust than the traditional inexact Newton method for high Reynolds number flows as well as for large number of processors.

References

[1] X.-C. Cai and D. E. Keyes, “Nonlinearly preconditioned inexact Newton algorithms,” *SIAM J. Sci. Comput.*, v. 24, p. 183-200, 2002.