Towards a three-dimensional moving body incompressible flow solver with a linear deformable model

牛仰堯
Mechanical Engineering
Engineering
yniu@chu.edu.tw

Abstract

In this study, a three-dimensional fluid–structured parallelized solver is extended from the previous work (Niu et al., 2009 [1]) for moving body simulations. Based on the unified Eulerian and Lagrangian coordinate transformations, the unsteady three-dimensional incompressible Navier–Stokes equations with artificial compressibility (Chorin, 1967 [2]) in a dual-time stepping approach are first derived. To implement unsteady flow calculations, the dual-time stepping strategy including the LU decomposition method is used in the pseudo-time iteration and the second-order accurate backward difference is adopted to discretize the unsteady flow terms. Also, a third-order Roe type flux limited splitting is derived to evaluate the spatial difference of the convective fluxes. The original FORTRAN code is converted to the MPI code and tested on a 64-CPU IBM SP2. The parallel strategy here is based on the partitions of all do-loops in the original FORTRAN code and transferring the calculations inside the do-loop into different CPUs. The partition of the do-loop can be applied on the innermost loop, only or the last two inner loops depending on two-dimensional or three-dimensional problems. This kind of the parallel data partition of the loops is independent of what kind of the explicit or implicit type numerical algorithm used. Therefore, the current parallel approach can take advantage of the MPI language fully to transfer data efficiently among CPUs even for solving the governing equation implicitly. The test results show that a significant reduction of computing time in running the model and a near-linear speed up rate is achieved up to 32 CPUs at IBM SP2. The speed up rate is as high as 31 for using 64 IBM SP2 processors The test shows efficient parallel processing to provide prompt simulation of 3D cavity, unsteady dropping airfoil and blood flows in an aortic tube with a linear elastic modeling of wall motion is included here.

Keyword：Fluid－structured interaction, Incompressible flow, Parallel computation, Chorin’s artificial compressibility